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Goodwin et al.

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[54] TROCAR ASSEMBLY

[75] Inventors: **Matthew S. Goodwin**, Cincinnati, Ohio; **Michael A. Murray**, Bellevue, Ky.

[73] Assignee: **Ethicon Endo-Surgery, Inc.**, Cincinnati, Ohio

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[51] **Int. Cl.**[6] **A61M 5/18**

[52] **U.S. Cl.** **604/164**; 604/272; 600/121

[58] **Field of Search** 604/158, 164, 604/166, 168, 264, 272; 606/15–16, 14; 607/93; 600/101, 114, 121, 129, 136

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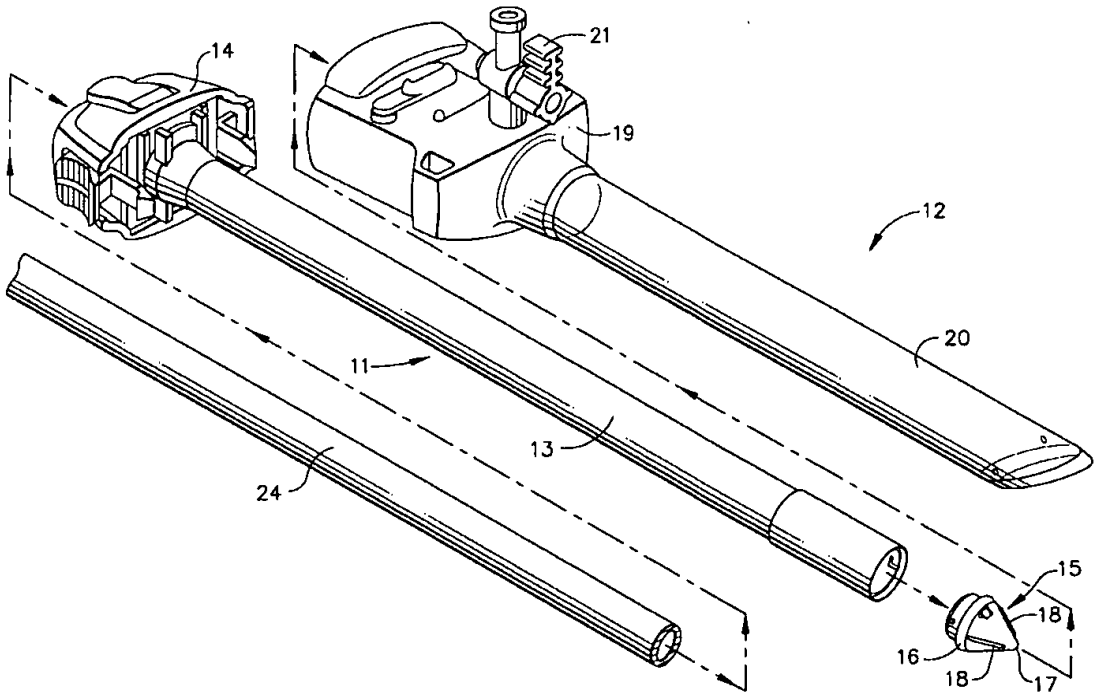
Primary Examiner—Ronald Stright
Assistant Examiner—Sharon Finkel
Attorney, Agent, or Firm—Matthew S. Goodwin

[57] **ABSTRACT**

A multi-patient use trocar assembly is disclosed. The trocar assembly has obturator and cannula subassemblies. The obturator subassembly has an elongated obturator shaft which can receive an endoscope at its distal end. The obturator shaft is reusable for multi-patient use. A transparent obturator tip is detachably mounted onto the end of the obturator shaft. The obturator tip is transparent and disposable. Because it is transparent, illuminated images provided by the endoscope within the body cavity can be transmitted through the obturator tip. Once the trocar assembly is used on a first patient, the obturator tip is detached and disposed of, and replaced with another obturator tip. Hospital costs are reduced because the trocar assembly can be reused multiple times, and only the obturator tip needs to be disposed of after each patient use.

16 Claims, 7 Drawing Sheets



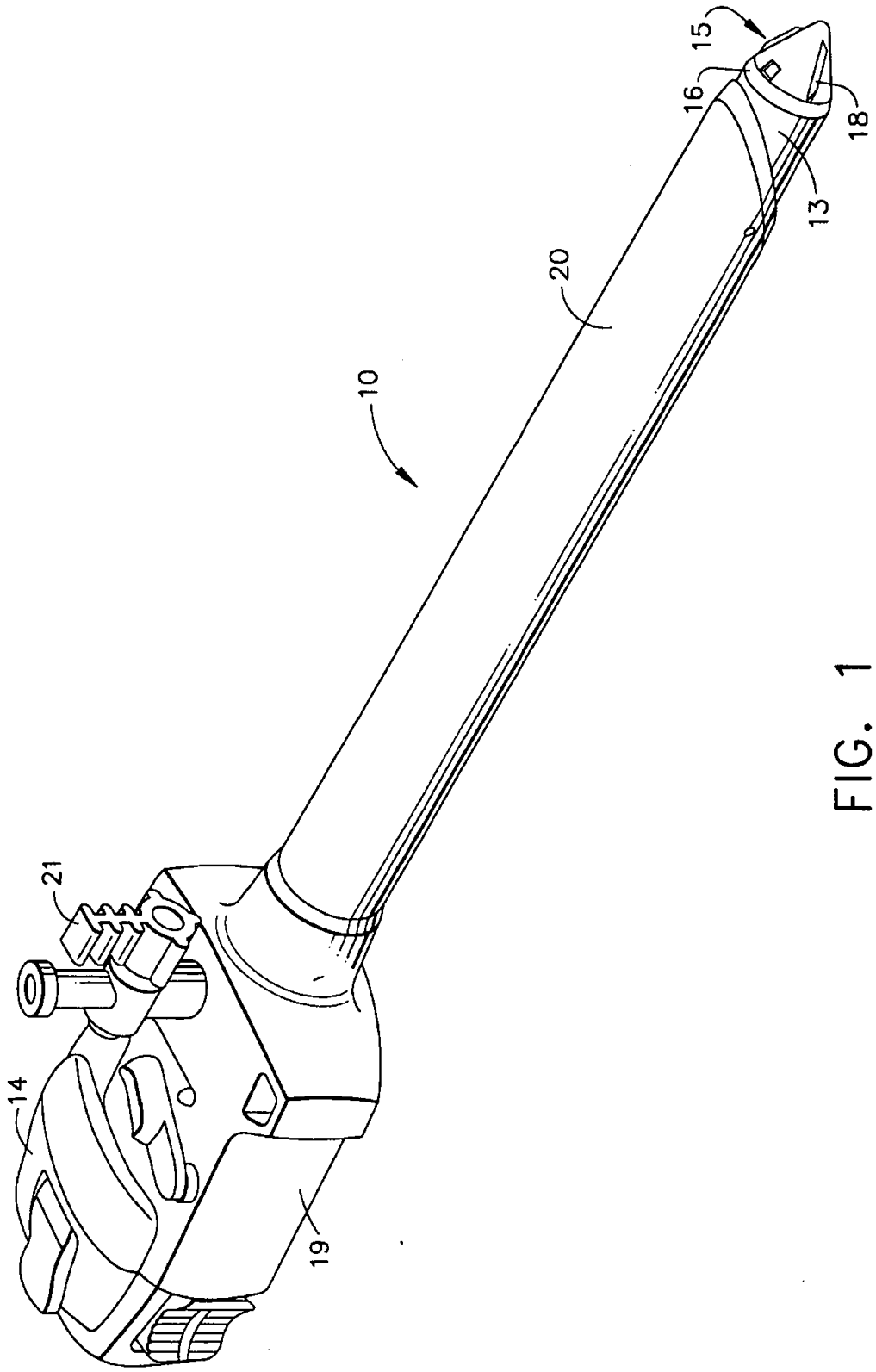
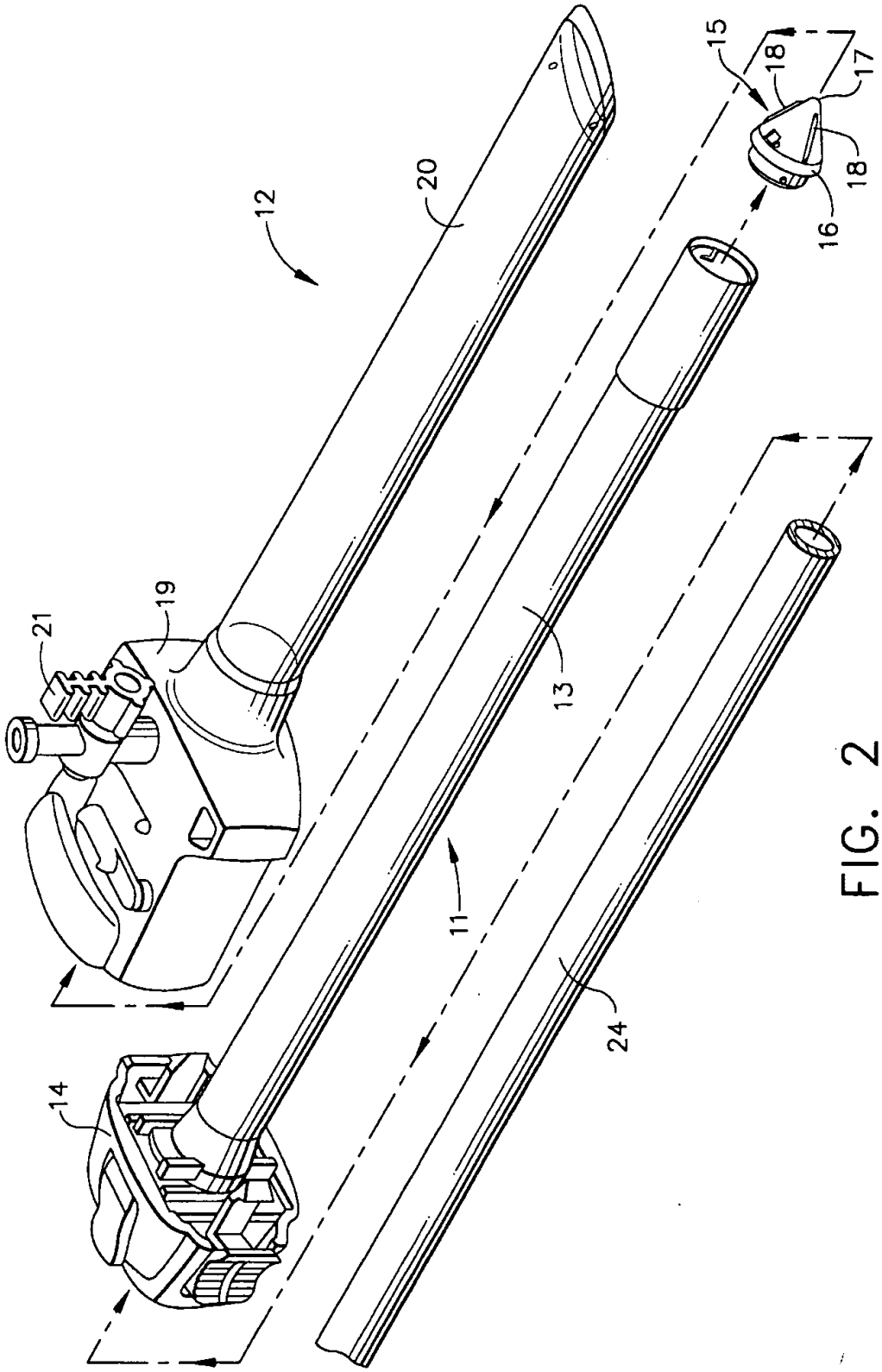


FIG. 1



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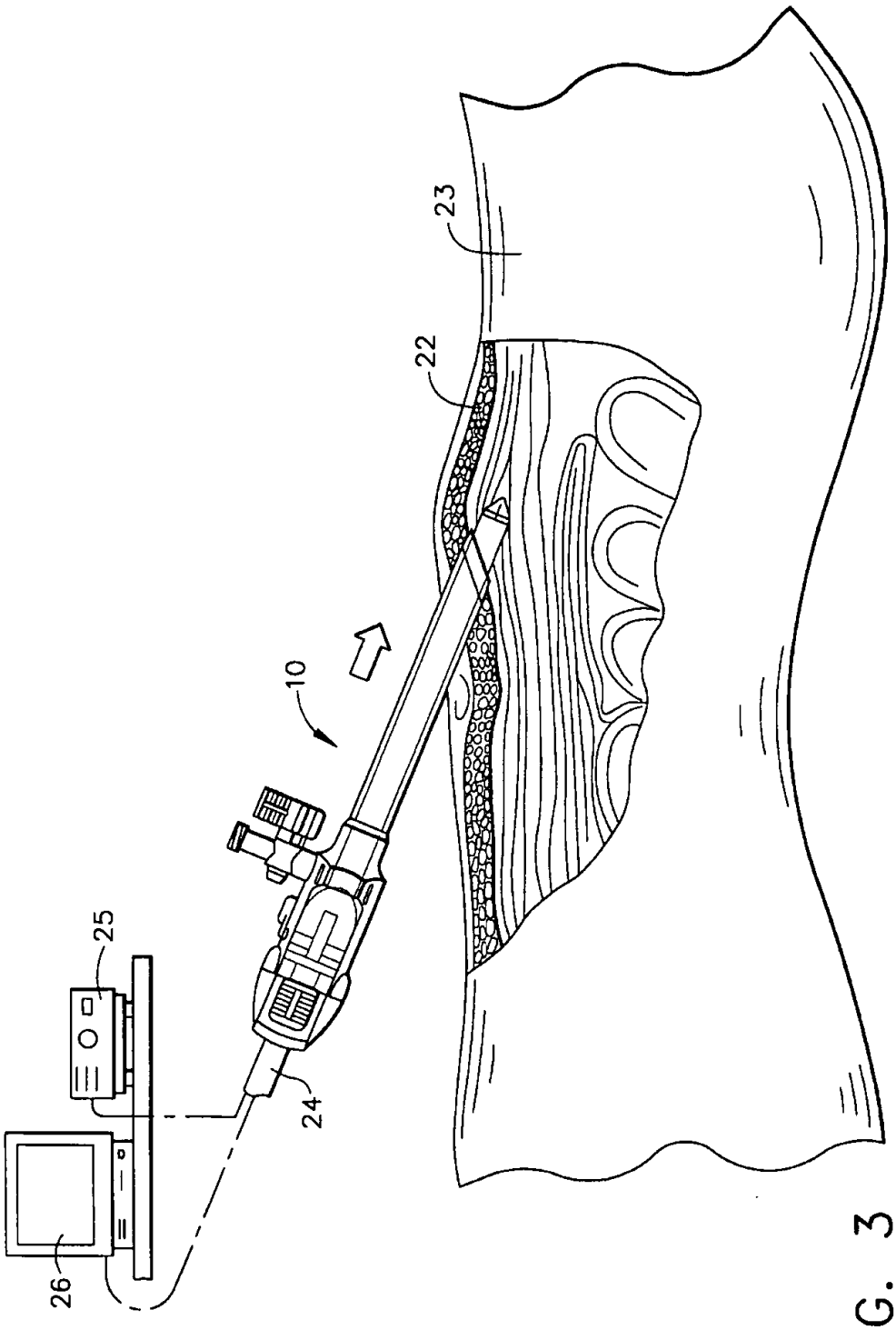

FIG. 3

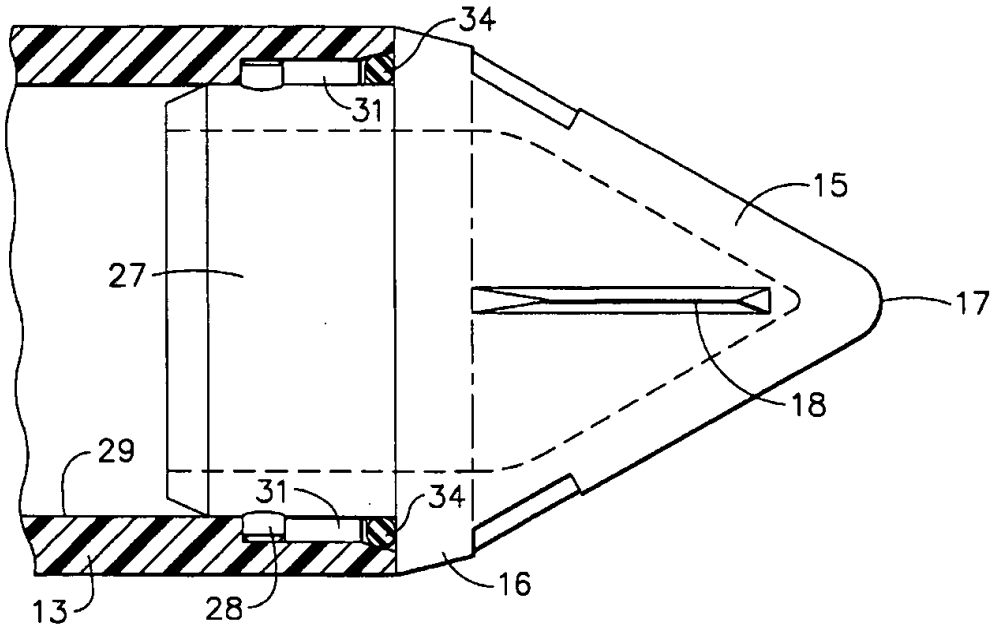
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FIG. 4

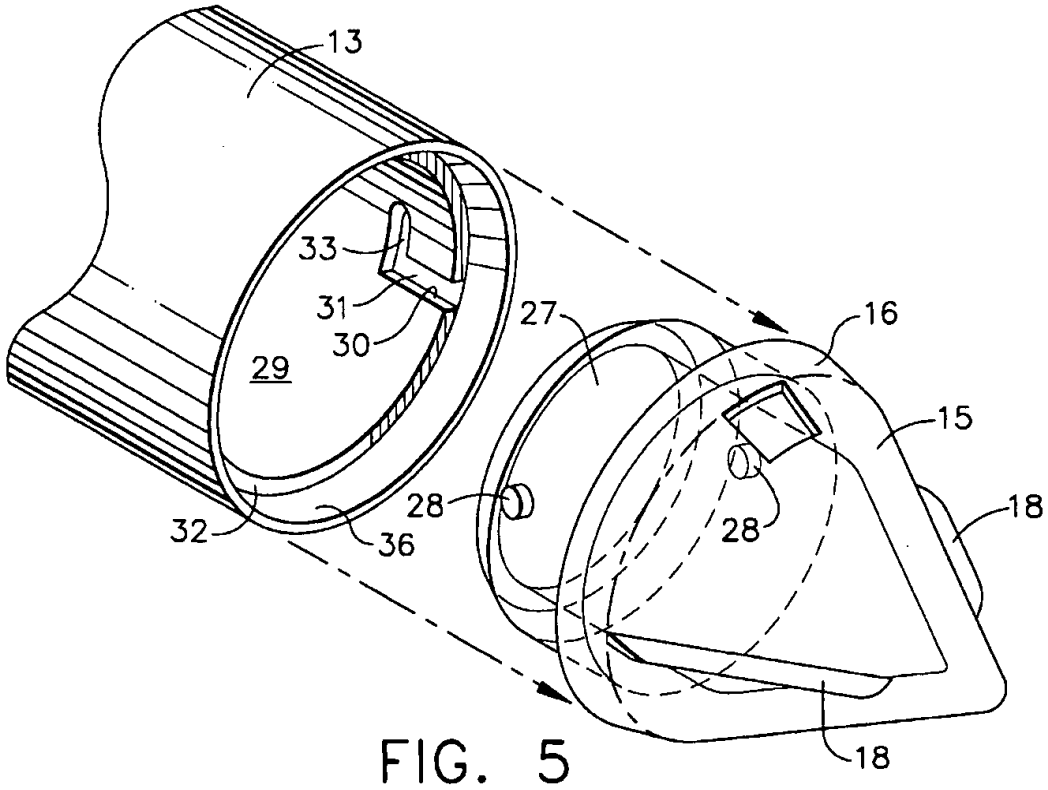
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FIG. 5

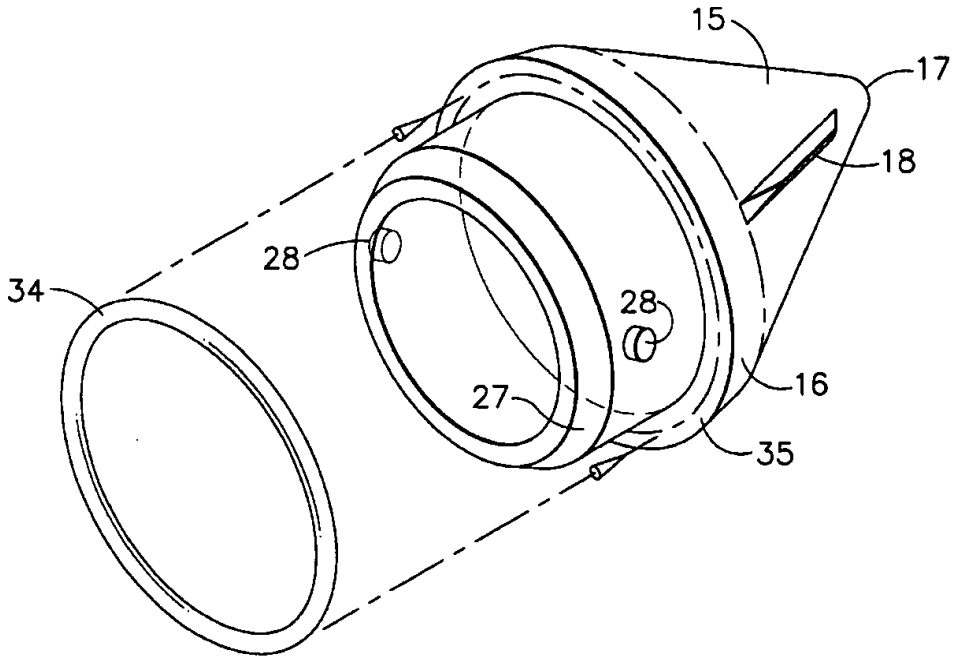

FIG. 6

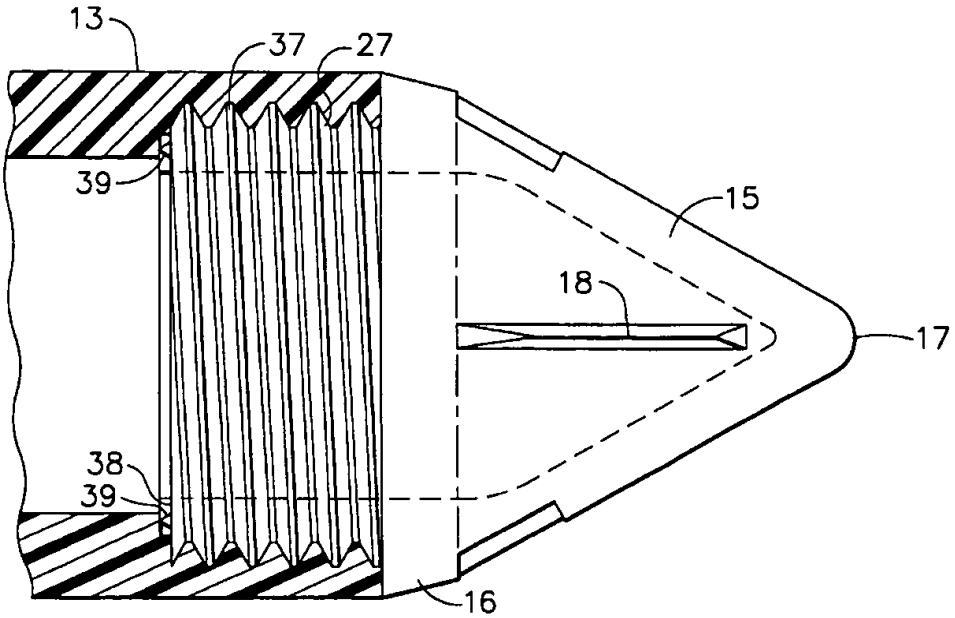

FIG. 7

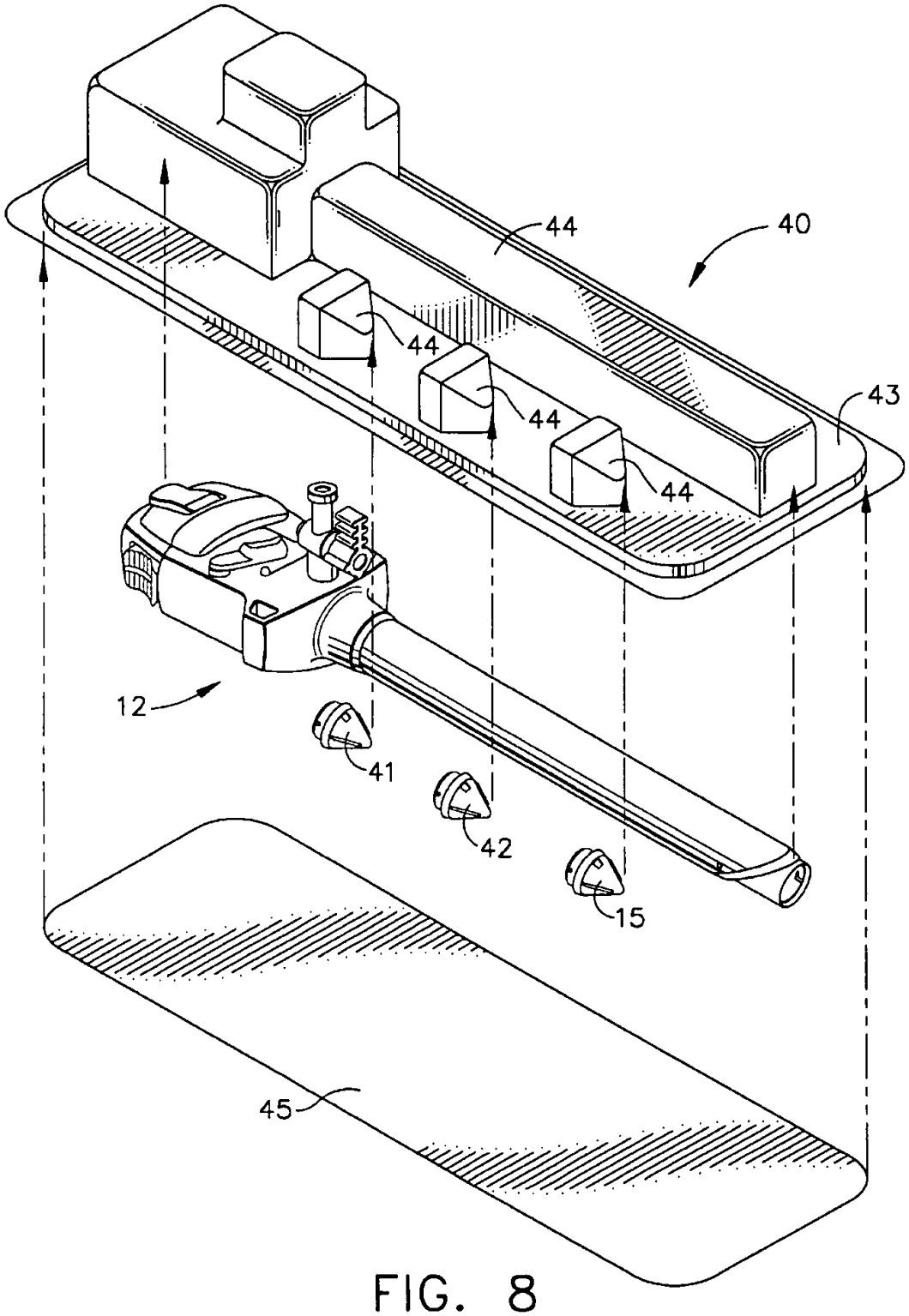

FIG. 8

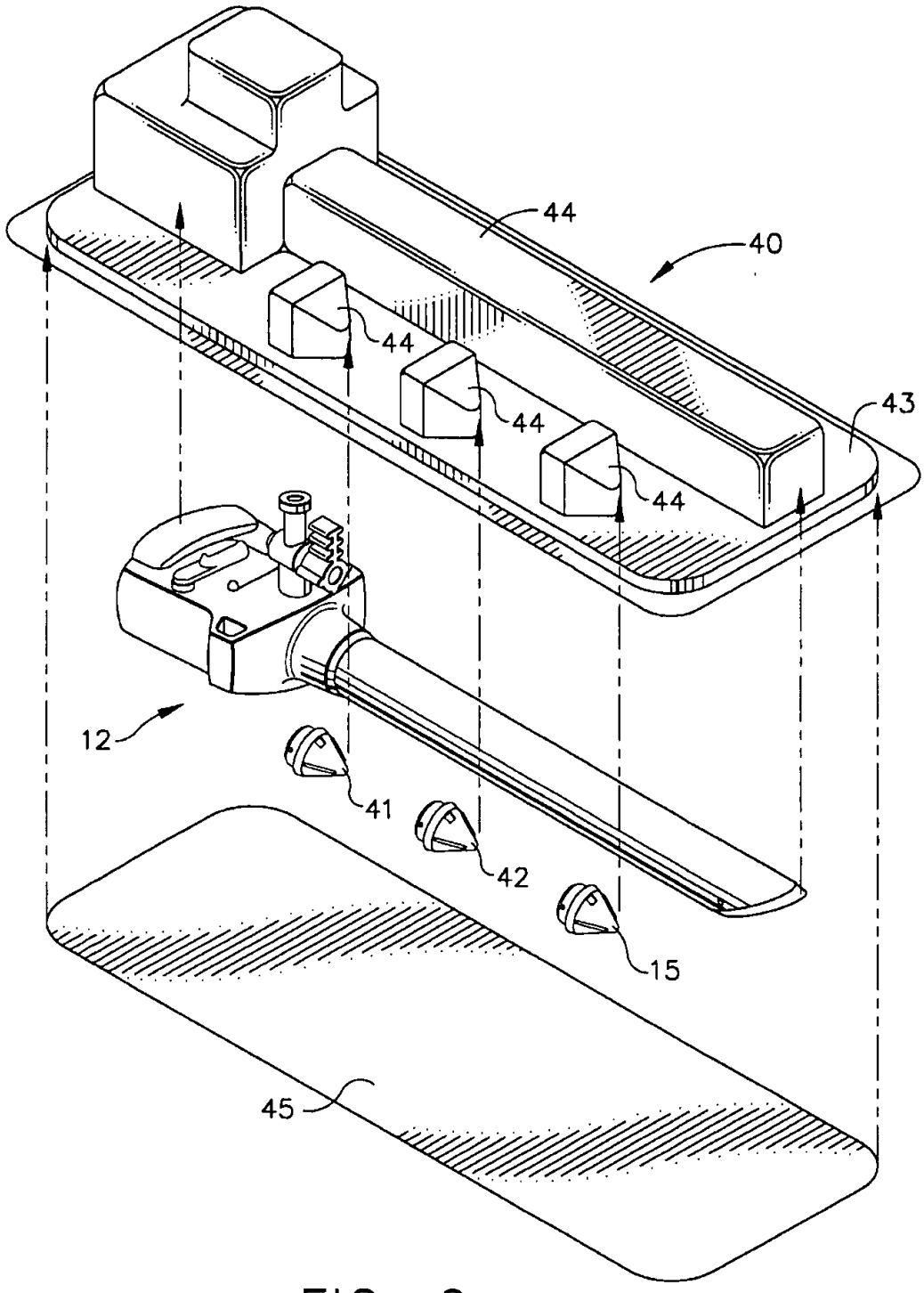

FIG. 9

TROCAR ASSEMBLY

BACKGROUND OF THE INVENTION

This invention relates to a trocar assembly for providing access to a surgical site within a body cavity during a minimally invasive surgical procedure. More particularly, it relates to a trocar assembly which has a long, reusable obturator shaft and a disposable obturator tip which can be attached and detached from the obturator shaft to enable multi-patient use of the trocar assembly.

Trocars have been available for providing access to a surgical site within a body cavity of a patient for a significant period of time. Of critical importance in the operation and use of trocars are the safety features of the trocar which minimize or prevent inadvertent puncture of body tissues or organs during initial penetration through the body wall. U.S. Pat. No. 4,535,773 describes numerous illustrations of trocars which have a shield to cover the sharp obturator tip when penetration of the body wall is completed. In a similar fashion, U.S. Pat. No. 4,601,710 describes a trocar where a shield is mounted concentrically around the obturator tip to cover the tip after the body wall has been penetrated. The '710 patent also states that the piercing tip can be adapted to be removable from the shaft.

Another type of trocar which is designed to minimize or prevent inadvertent puncture of body tissue during penetration is described in U.S. Pat. No. 5,271,380. The '380 patent describes a trocar which has a transparent obturator tip. Fiber optic cables are contained within the obturator shaft to provide illumination of the operative site and transmission of illuminated images through the transparent obturator tip to enable the user to visualize the penetration of tissue layers as the trocar is being used. Accordingly, a shield to cover the obturator tip of the trocar is unnecessary.

Another trocar which provides visualization during penetration is described in U.S. Pat. No. 5,380,291. The '291 patent describes a trocar with an obturator which has a hollow shaft for receiving an endoscope, and a transparent obturator tip for transmitting illuminated images provided by the endoscope from the body tissue through the transparent tip during tissue penetration. Another trocar which has similar features is described in U.S. Pat. No. 5,441,041.

While safety is a significant concern in connection with the design of trocars, so is cost and surgical waste generated from the use of disposable trocars. Accordingly, multi-patient use trocars have become popular and are now being described in the patent literature. For example, U.S. Pat. Nos. 5,383,860; 5,496,280 and 5,549,565 describe trocars which have reusable cannulas adapted for multiple patient use coupled to cannula housings where the entire housing or a portion of the housing is disposed of and replaced after a single patient use. U.S. Pat. No. 5,256,147 describes a reusable trocar which has an obturator with a replaceable tip portion. The ability to reuse trocar assemblies saves hospital money, and as pressure increases to reduce and minimize hospital costs, alternatives which these trocars exemplify are becoming more attractive to hospital personnel.

The ability to minimize surgical waste is also possible by varying the way in which surgical components are packaged and distributed to end users. For example, U.S. Pat. No. 5,144,942 describes a surgical kit which includes a plurality of trocar cannulas for each trocar obturator in the kit package. The obturator can be used with each of the cannula sleeves to provide numerous access ports during minimally invasive surgery without the need to package a trocar obturator with each cannula sleeve. Another kit patent which describes a combination of shielded and non-shielded trocar assemblies is U.S. Pat. No. 5,453,094.

Although safety, cost and reduction in packaging contents to reduce surgical waste have all been factors which have been considered in the design and packaging of trocars, there are problems which still need to be addressed. Specifically, what is needed is a trocar assembly which can provide visualization concurrently with tissue penetration, and is adapted for multi-patient use at lower cost. In particular, it would be desirable if a trocar assembly providing for visualization could be fabricated which has a reusable obturator for use on multiple patients to lower cost. Further, it would be particularly desirable if such a trocar assembly could be fabricated which is convenient and easy to use.

SUMMARY OF THE INVENTION

The invention is a multi-patient use trocar assembly for providing access to surgical sites within body cavities of multiple patients during minimally invasive surgical procedures. The trocar assembly comprises two subassemblies. The subassemblies are an obturator subassembly and a cannula subassembly.

The obturator subassembly has an elongated obturator shaft, a first obturator tip and an obturator grip. The elongated obturator shaft has proximal and distal ends and an opening in the shaft adjacent the shaft distal end for receiving an endoscope. The obturator shaft is reusable and adapted for use on multiple patients.

The first obturator tip is detachably mounted onto the distal end of the obturator shaft. The tip extends distally from the shaft distal end. The first obturator tip is transparent. The first obturator tip is capable of transmitting illuminated images provided by the endoscope from the body cavity through the transparent tip. It is shaped to enlarge an opening through a body wall as the trocar assembly is advanced toward any one of the surgical sites. The first obturator tip is disposable following use on a first patient.

The obturator grip is attached to the proximal end of the obturator shaft. It facilitates the manipulation of the obturator subassembly.

The cannula subassembly removably receives the obturator subassembly. The cannula subassembly has a cannula housing and an elongated cannula tube attached to the cannula housing. The cannula tube surrounds the obturator shaft of the obturator subassembly when the obturator shaft is received in the cannula subassembly.

Following use of the trocar assembly to provide access for the first patient, the first obturator tip is removed from the distal end of the obturator shaft. The first obturator tip is disposed of, and a second obturator tip is mounted on the shaft distal end for use of the trocar subassembly to provide access for a second patient.

The trocar assembly of this invention has a reusable obturator shaft for multi-patient use, and a disposable transparent obturator tip which is detached from the distal end of the obturator shaft following a single patient use. A second transparent tip can then be attached to the reusable obturator shaft, and the trocar assembly can be used to provide access to the surgical site of the second patient. Since the obturator shaft is reusable, and the disposable transparent obturator tip is detachable, the trocar assembly can be used to provide access for multiple patients without the need to dispose of the entire trocar assembly. Instead, only the transparent obturator tip needs to be disposed of and replaced, and the rest of the trocar assembly can be used again.

Accordingly, the trocar assembly of this invention provides for visualization concurrently with tissue penetration

when used in combination with an endoscope for the transmission of illuminated images from the body cavity through the transparent obturator tip. It provides for visualization at a cost significantly lower than similarly featured trocar assemblies described in the patent literature. Furthermore, the trocar assembly of this invention is easy and convenient to use.

The trocar of this invention is especially useful during a minimally invasive surgical procedure where an access port is needed to provide a passageway for the insertion and withdrawal of endoscopic instruments. However, the trocar assembly can be used in open surgical procedures as well.

BRIEF DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 is a perspective view of a preferred multi-patient use trocar assembly of this invention.

FIG. 2 is an exploded perspective view of the trocar assembly of FIG. 1 illustrating the detachable mounting of the disposable obturator tip to the reusable shaft of the obturator subassembly, and further illustrating the trocar assembly in cooperation with an endoscope.

FIG. 3 is a side elevational environmental view partially in section illustrating the use of the trocar assembly of FIG. 1 in combination with an endoscope.

FIG. 4 is a side elevational view of the preferred disposable obturator tip in cooperation with a fragmentary sectional view of a reusable obturator shaft, particularly illustrating a preferred embodiment for detachably mounting the obturator tip to the obturator shaft.

FIG. 5 is an exploded perspective view further illustrating the mounting of the tip to the shaft as shown in FIG. 4.

FIG. 6 is a perspective view of the obturator tip illustrated in FIGS. 4 and 5 in combination with a preferred tip seal.

FIG. 7 is a side elevational view of the preferred obturator tip in cooperation with a fragmentary sectional view of a reusable obturator shaft illustrating another preferred embodiment for detachably mounting and sealing the obturator tip to the shaft.

FIG. 8 is an exploded package assembly illustrating a surgical kit which contains a trocar assembly and first, second and third disposable obturator tips.

FIG. 9 is an exploded package assembly illustrating a surgical kit containing a cannula subassembly and three disposable obturator tips.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A preferred trocar assembly 10 of this invention particularly configured for providing access ports during minimally invasive surgery on multiple patients in an economically efficient manner is illustrated in FIGS. 1 and 2. The trocar assembly has two interfitting subassemblies. The obturator subassembly 11 penetrates or dissects through the tissue layers of the patient to provide an opening adjacent the surgical site. The cannula subassembly 12 provides the access portal for insertion and withdrawal of various surgical instruments through the opening created by the penetration or dissection of the tissue layers with the obturator subassembly.

The obturator subassembly 11 has three primary components. It has a long, hollow obturator shaft 13. The shaft is rigid to withstand the force exerted on the tissue layers when penetration or dissection through the tissue is performed. The shaft is composed of a material which enables the reuse of the obturator shaft on multiple patients. Advantageously, the reusable shaft is composed of a metal such as stainless steel, aluminum or titanium, or a plastic such as a polysulfone or a plastic sold by General Electric under the trademark ULTEM. Preferably, the reusable shaft is composed of stainless steel. At the proximal end of the obturator shaft 13, there is affixed an obturator grip 14 for manipulating the obturator subassembly. At the distal end of the obturator shaft, a first obturator tip 15 is detachably mounted to the shaft distal end (the specific details illustrating how the obturator tip is detachably mounted to the shaft distal end are discussed in connection with FIGS. 4–7 below). The obturator tip facilitates the penetration or dissection of the tissue layers as the trocar assembly is inserted through the tissue layers toward the surgical site, and is therefore shaped to enlarge an opening in the tissue as the trocar assembly is inserted toward the internal surgical site.

In contrast to the reusable obturator shaft, the obturator tip 15 is composed of a disposable material. Accordingly, following the use of the trocar assembly on a first patient, the first obturator tip is detached from the shaft distal end, the first obturator tip is disposed of, and a second disposable obturator tip is then mounted onto the shaft distal end so that the obturator subassembly can be reused on a second surgical patient. Furthermore, the obturator tip is composed of a transparent material so that the obturator tip acts as a transparent window enabling concurrent visualization during penetration or dissection when an endoscope is used, as discussed in more detail below.

The obturator tip 15 preferably has a conical configuration to facilitate the penetration or dissection of tissue. The conical tip has a tip base 16 with a base diameter substantially equivalent to that of the shaft diameter. At the opposite end of the obturator tip, spaced from the tip base, is an apex 17. Lastly, a pair of blunt-edged blades 18, or tissue separators, spaced 180° from each other, extend from the surface of the obturator tip to further facilitate the penetration or dissection of tissue.

Advantageously, the disposable obturator tip is composed of rigid plastic such as a polycarbonate, co-polyester or acrylic. The preferred material of construction for the disposable obturator tip is co-polyester.

The cannula subassembly 12 of the trocar assembly 10 has a cannula housing 19 and an elongated cannula tube 20 extending from the housing. The cannula housing has a stopcock 21 for the selective passage of a pressurizing fluid such as carbon dioxide to insufflate the body cavity during a minimally invasive surgical procedure, if desired. The elongated cannula tube receives the obturator shaft 13 when the obturator subassembly is inserted into and through the cannula housing and tube. When inserted, the obturator grip 14 can be latched onto the cannula housing 19. The disposable obturator tip 15, and a portion of the distal end of the reusable obturator shaft, extend from the distal end of the cannula tube when the obturator grip is latched onto the cannula housing.

When a first obturator tip is mounted onto the shaft distal end, and the obturator subassembly is inserted fully through the cannula subassembly so that the cannula tube receives the obturator shaft and the obturator grip is latched onto the cannula housing, the trocar assembly is now ready for the penetration or dissection of tissue on a first patient while providing simultaneous visualization as the tissue is penetrated or dissected. As illustrated in FIG. 3, the trocar assembly is advanced in the direction illustrated by the

arrow through various tissue layers 22 of a first surgical patient 23. A conventional endoscope 24 (depicted in FIG. 2) can be inserted through the hollow obturator shaft of the obturator subassembly so that the endoscope is positioned adjacent the proximal end of the transparent obturator tip. The endoscope is connected to a light source 25 to provide illumination through the transparent obturator tip to the surgical site. It is also connected to a video monitor 26 to display the illuminated images transmitted from the surgical site. In this way, the surgeon can readily monitor the advance of the trocar assembly through the tissue layers from the video monitor.

When the advancement of the trocar assembly is completed on the first patient, the obturator subassembly and the endoscope may be removed from the cannula subassembly. An access portal is therefore provided through the cannula tube of the cannula subassembly so that additional instrumentation can then be inserted and withdrawn through the cannula subassembly to the surgical site to complete a desired surgical procedure on the first patient. When the surgical procedure is completed on the first patient, the disposable obturator tip can be detached from the obturator shaft, a second obturator tip can be subsequently attached to the obturator shaft, and the trocar assembly (with or without a new cannula subassembly) can be used on a second patient after appropriate cleaning and sterilization. In this manner, the trocar assembly can be used on multiple patients while enjoying the economic advantages attendant with the ability to reuse the obturator shaft.

FIGS. 4–6 illustrate a first preferred embodiment of the structure for detachably mounting the disposable obturator tip 15 to the distal end of the obturator shaft. The obturator tip has an annulus 27 descending from the base 16 of the obturator tip. When attached to the shaft distal end, the annulus descends through the interior of the shaft distal end. The annulus has a pair of attachment pins 28 extending from the annulus wall and spaced about 180° from each other. Correspondingly, the inner wall 29 of the obturator shaft at the distal end of the obturator shaft has a pair of receiving slots 30 for receiving the attachment pins extending from the interior annulus of the obturator tip. Each of the receiving slots has a longitudinal channel section 31 descending proximally from a distal edge surface 32 at the shaft distal end, and a circumferential slot section 33 spaced from the distal edge surface of the obturator shaft (only one of the circumferential slot sections is illustrated in FIG. 5). The mounting mechanism can, therefore, be best viewed as a "twist-lock" mechanism because when the surgeon or operating room assistant wants to mount the obturator tip to the shaft distal end, he initially guides the attachment pins through the longitudinal channel section of the receiving slots, and then twists the obturator tip to guide the pins through the circumferential slot sections to secure the obturator tip to the shaft distal end. When the surgeon or operating room assistant wants to remove the tip from the shaft distal end, the procedure is simply reversed.

In a particularly preferred embodiment, a sealing structure is provided between the obturator tip and the shaft distal end to prevent the leakage of insufflation gas through the trocar assembly or bodily fluids from penetrating into the interior space of the transparent obturator tip, thus interfering with optimum visual acuity during use. Of course, the sealing structure facilitates the attachment and detachment of the transparent obturator tip. An "O" ring elastomeric seal 34 is fitted between a seal stop 35 located on the underside of the tip base of the obturator tip, and the distal edge surface 32 of the obturator shaft. As a way of advantageously distributing the pressure exerted on the seal when the obturator tip is attached to the shaft distal end, a seal chamfer 36 extends from the distal edge surface of the obturator shaft.

Another embodiment of a preferred structure for detachably mounting the transparent obturator tip to the shaft distal end is illustrated in FIG. 7. A simple mating threaded attachment 37 is provided between the interior annulus 27 descending from the tip base 16 of the obturator tip 15, and the shaft distal end. The interior annulus of the obturator tip is threaded, and the distal end of the obturator shaft has mating threads to receive the threaded annulus. A seal ring or washer 38 is integrally attached to the proximal end of the threaded annulus of the obturator tip. The integral ring has a deformable ring apex which is deformed when the obturator tip is screwed into the shaft distal end, and the ring apex 39 of the seal ring bears upon the distal edge surface of the obturator shaft.

Referring now to FIGS. 8 and 9, there are shown packaging options to take advantage of the unique features of the trocar assembly of this invention. FIG. 8 illustrates a packaging enclosure 40 which includes the preferred trocar assembly 10 of this invention with its first transparent, disposable obturator tip 15. Significantly, also included in the packaging enclosure are second and third disposable transparent obturator tips, 41 and 42, respectively. The trocar assembly and the obturator tips are packaged as a single package enclosure in a surgical kit. The surgical kit includes a bottom shipping tray 43 containing multiple cavities 44 therein for receiving the various components of the kit. It also includes a top lid 45 which is affixed over the bottom shipping tray to provide an integrated packaging unit for a surgical kit. In another packaging configuration particularly illustrated in FIG. 9, the integrated packaging enclosure 40 of the surgical kit contains the cannula subassembly 12 of the trocar assembly and the first, second and third disposable obturator tips. Advantageously, in this embodiment, the reusable obturator shaft which is purchased with an initial purchase of a trocar assembly can be reused on multiple patients, and a kit simply containing a cannula subassembly of the disposable obturator kits can be purchased to provide a fully integrated trocar assembly. When this kit configuration is used, as well as other kit configurations taking advantage of the reusable nature of the obturator shaft and disposability of the obturator tips and cannula subassemblies, it is unnecessary to purchase the entire trocar assembly for each access portal desired. Therefore, instrumentation costs are lowered and the packaging waste is minimized.

In another embodiment of the invention, a kit which contains a plurality of transparent obturator tips is provided in a single package enclosure. This is particularly advantageous when not only the obturator shaft is reusable, but also the cannula subassembly as well.

Although this invention has been described in connection with its most preferred embodiments, numerous additional embodiments can be readily envisioned by those skilled in this art. For example, those skilled in this art can readily envision numerous additional attachment mechanisms for detachably mounting the disposable obturator tip to the reusable obturator shaft. Likewise, numerous surgical kit configurations providing an integrated packaging enclosure which utilizes the unique features of the trocar assembly of this invention can be readily envisioned by those skilled in this art. Accordingly, the reader should recognize that the scope of this invention is not in any way limited to the specific embodiments described in this detailed description, but rather is defined by the claims which appear below.

What is claimed is:

1. A multi-patient use trocar assembly for providing access to surgical sites within body cavity of multiple patients during minimally invasive surgical procedures, said assembly comprising:

an obturator subassembly having (i) an elongated obturator shaft with proximal and distal ends and an opening therein adjacent said shaft distal end for receiving an endoscope, said obturator shaft being reusable and adapted for use on said multiple patients, (ii) a first obturator tip detachably mounted onto said shaft distal end and extending distally therefrom, said first obturator tip being transparent for transmitting illuminated images provided by said endoscope from the body cavity through said transparent tip, said first obturator tip shaped to enlarge an opening through a body wall as said trocar assembly is advanced toward any of said surgical sites, and said first obturator tip being disposable following use on a first patient, (iii) an obturator grip attached to said obturator shaft proximal end for facilitating manipulation of said obturator subassembly, and (iv) a seal mounted adjacent said shaft distal end for facilitating attachment and detachment of said first obturator tip; and

a cannula subassembly for removably receiving said obturator subassembly, said cannula subassembly having (i) a cannula housing, and (ii) an elongated cannula tube attached to said cannula housing, said cannula tube surrounding said obturator shaft when said obturator shaft is received in said cannula subassembly.

2. The trocar assembly of claim 1 wherein said elongated obturator shaft has a longitudinal axis and an outside diameter, and each of said first and second obturator tips has a tip base adjacent said shaft distal end, said tip base having a base diameter about equal to said outside diameter of said obturator shaft.

3. The trocar assembly of claim 2 wherein each of said first and second obturator tips is symmetrical about the longitudinal axis of said obturator shaft.

4. The trocar assembly of claim 3 wherein each of said first and second obturator tips has an apex spaced from said tip base.

5. The trocar assembly of claim 4 wherein each of said first and second obturator tips is a conical tip.

6. The trocar assembly of claim 2 wherein each of said first and second obturator tips has an annulus descending from said tip base of each of said tips, and when each of said tips is attached to said shaft distal end, said annulus is located interiorly of said shaft distal end.

7. The trocar assembly of claim 6 wherein said annulus has a pair of attachment pins extending therefrom.

8. The trocar assembly of claim 7 wherein said obturator shaft has an inner wall, and said inner wall has a pair of receiving slots for receiving said attachment pins extending from said annulus of each of said obturator tips so as to detachably mount each of said tips to said shaft distal end.

9. The trocar of claim 8 wherein said shaft distal end has a distal edge surface, and each of said receiving slots has a longitudinal channel section descending proximally from said distal edge surface, and a circumferential slot section spaced from said distal edge surface.

10. The trocar assembly of claim 2 wherein said seal is fitted between said shaft distal end and said tip base of each said first and second obturator tips.

11. The trocar assembly of claim 10 wherein said seal is an "O" ring elastomeric seal.

12. The trocar assembly of claim 11 wherein said shaft distal end has a distal edge surface, said tip base has a seal stop located on an underside surface of said tip base, and said "O" ring seal is fitted between said distal edge surface and said seal stop.

13. The trocar assembly of claim 6 wherein said annulus descending from said tip base and said shaft distal end have mating threads for detachably threading each of said obturator tips to said shaft distal end.

14. The trocar assembly of claim 13 wherein said seal is integrally attached to said threaded annulus descending from said tip base.

15. The trocar assembly of claim 14 wherein said seal has a deformable ring apex thereon.

16. A method for providing access to surgical sites within body cavities of multiple patients during minimally invasive surgical procedures, said method comprising:

a) providing a multi-patient use trocar assembly which includes:

an obturator subassembly having (i) an elongated obturator shaft with proximal and distal ends and an opening therein adjacent said shaft distal end for receiving an endoscope, said obturator shaft being reusable and adapted for use on said multiple patients, (ii) a first obturator tip detachably mounted onto said shaft distal end and extending distally therefrom, said first obturator tip being transparent for transmitting illuminated images provided by said endoscope from the body cavity through said transparent tip, said first obturator tip shaped to enlarge an opening through a body wall as said trocar assembly is advanced toward any of said surgical sites, and said first obturator tip being disposable following use on a first patient, and (iii) an obturator grip attached to said obturator shaft proximal end for facilitating manipulation of said obturator subassembly; and

a cannula subassembly for removably receiving said obturator subassembly, said cannula subassembly having (i) a cannula housing, and (ii) an elongated cannula tube attached to said cannula housing, said cannula tube surrounding said obturator shaft when said obturator shaft is received in said cannula subassembly;

b) using said trocar assembly to provide access for said first patient;

c) removing said first obturator tip from said shaft distal end for disposal thereof following use of said trocar assembly to provide access for said first patient;

d) mounting a second obturator tip on said shaft distal end; and

e) using said trocar assembly with said second obturator tip mounted on said shaft distal end to provide access for said second patient.

* * * * *

US005441041A

United States Patent [19]

Sauer et al.

[11] Patent Number: 5,441,041

[45] Date of Patent: Aug. 15, 1995

[54] OPTICAL TROCAR

[75] Inventors: Jude S. Sauer, Pittsford; Michael G. Oravecz, Rochester; Roger J. Greenwald, Holley; Alexander I. Kobilansky, Pittsford, all of N.Y.

[73] Assignee: United States Surgical Corporation, Norwalk, Conn.

[21] Appl. No.: 120,489

[22] Filed: Sep. 13, 1993

[51] Int. Cl.[6] A61B 1/00

[52] U.S. Cl. 600/106; 606/185; 604/264; 600/160

[58] Field of Search 126/4, 3; 604/164, 165, 604/166, 167, 264, 272; 606/185, 184

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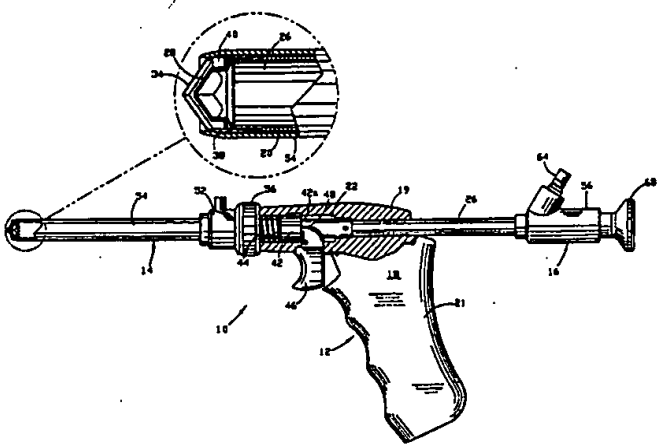
Primary Examiner—Richard J. Apley
Assistant Examiner—Beverly A. Meindl

[57] ABSTRACT

The present invention relates to an optical obturator which includes a sleeve having a longitudinal bore between a proximal end and a distal end. The longitudinal bore of the sleeve is configured to receive at least a portion of an endoscope or like image transferring system. An image directing member is positioned at the distal end of the sleeve and is provided to direct optical images into the longitudinal bore of the sleeve. A movable blade is positioned distal to the image directing member to facilitate penetration of body tissue.

14 Claims, 4 Drawing Sheets



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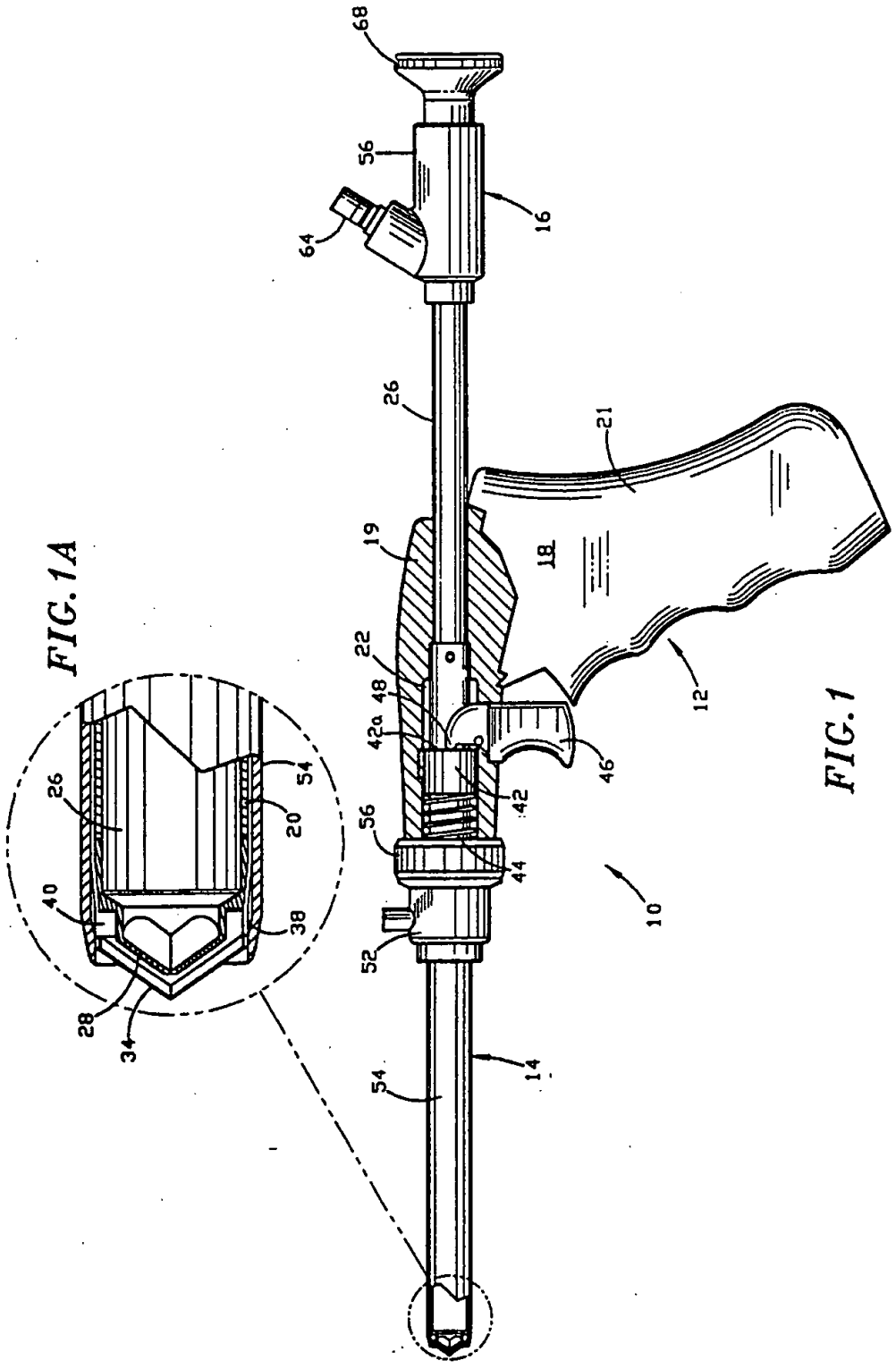
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FIG. 1

FIG. 1A

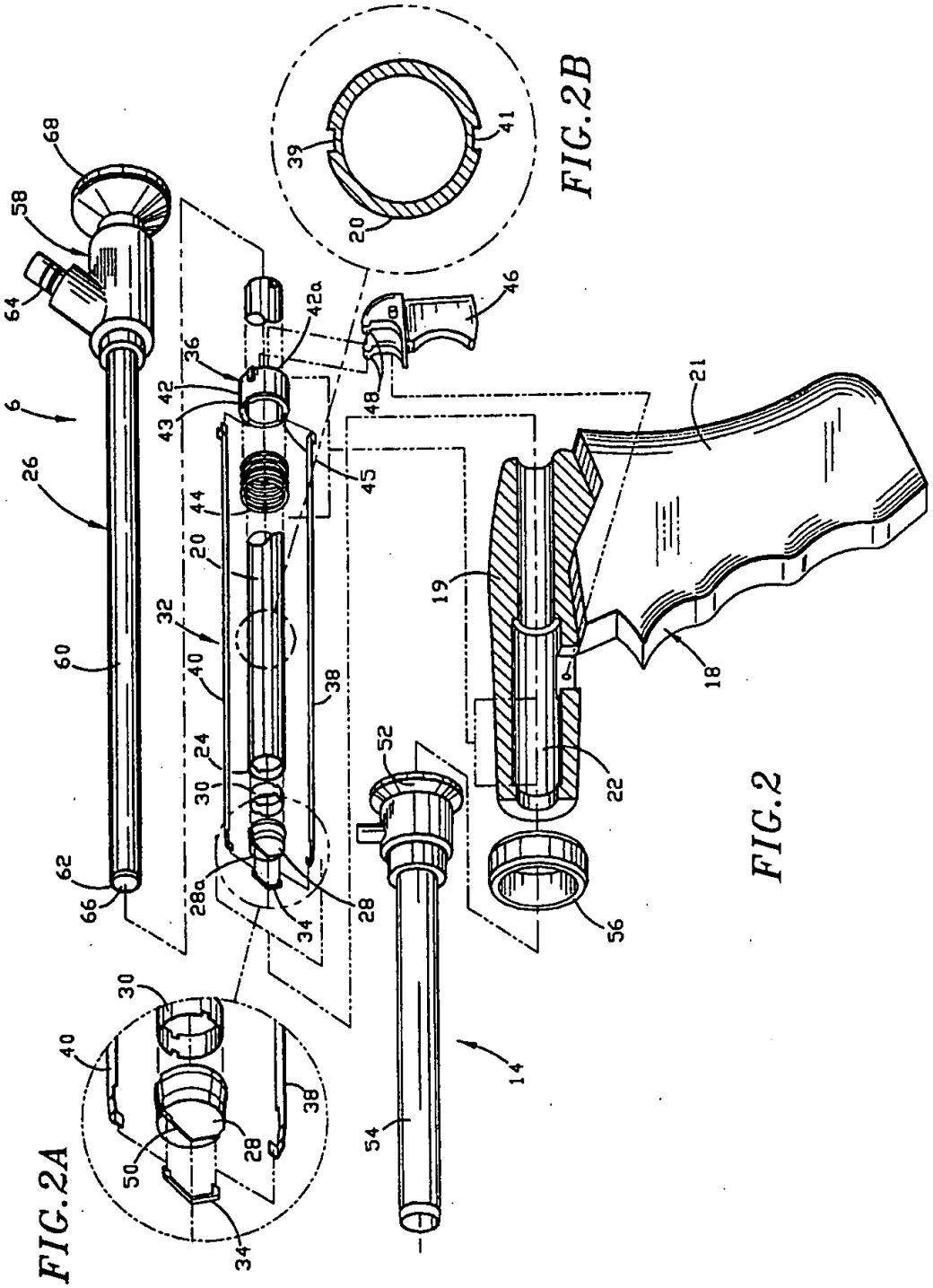
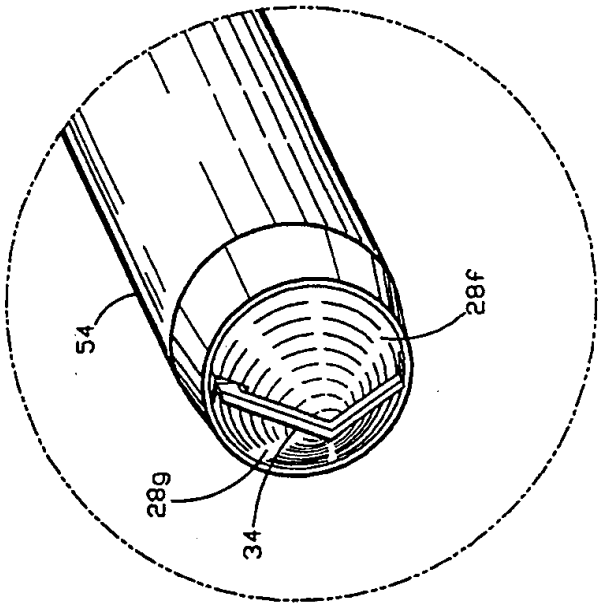


FIG.2B

FIG.2

FIG.2A

FIG. 4



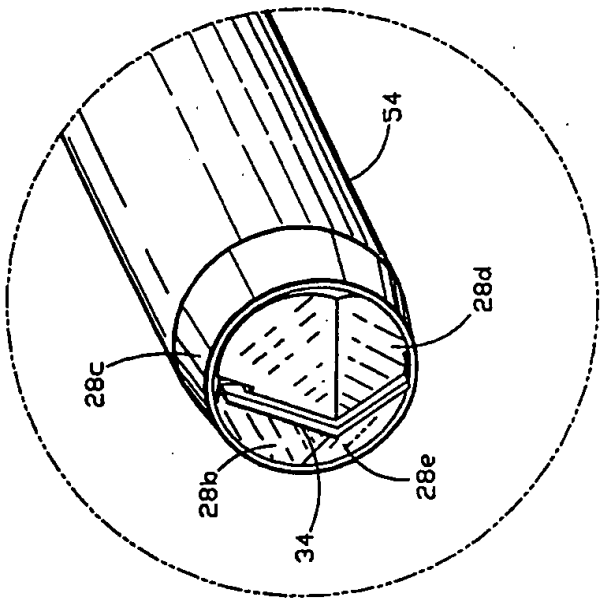


FIG. 3

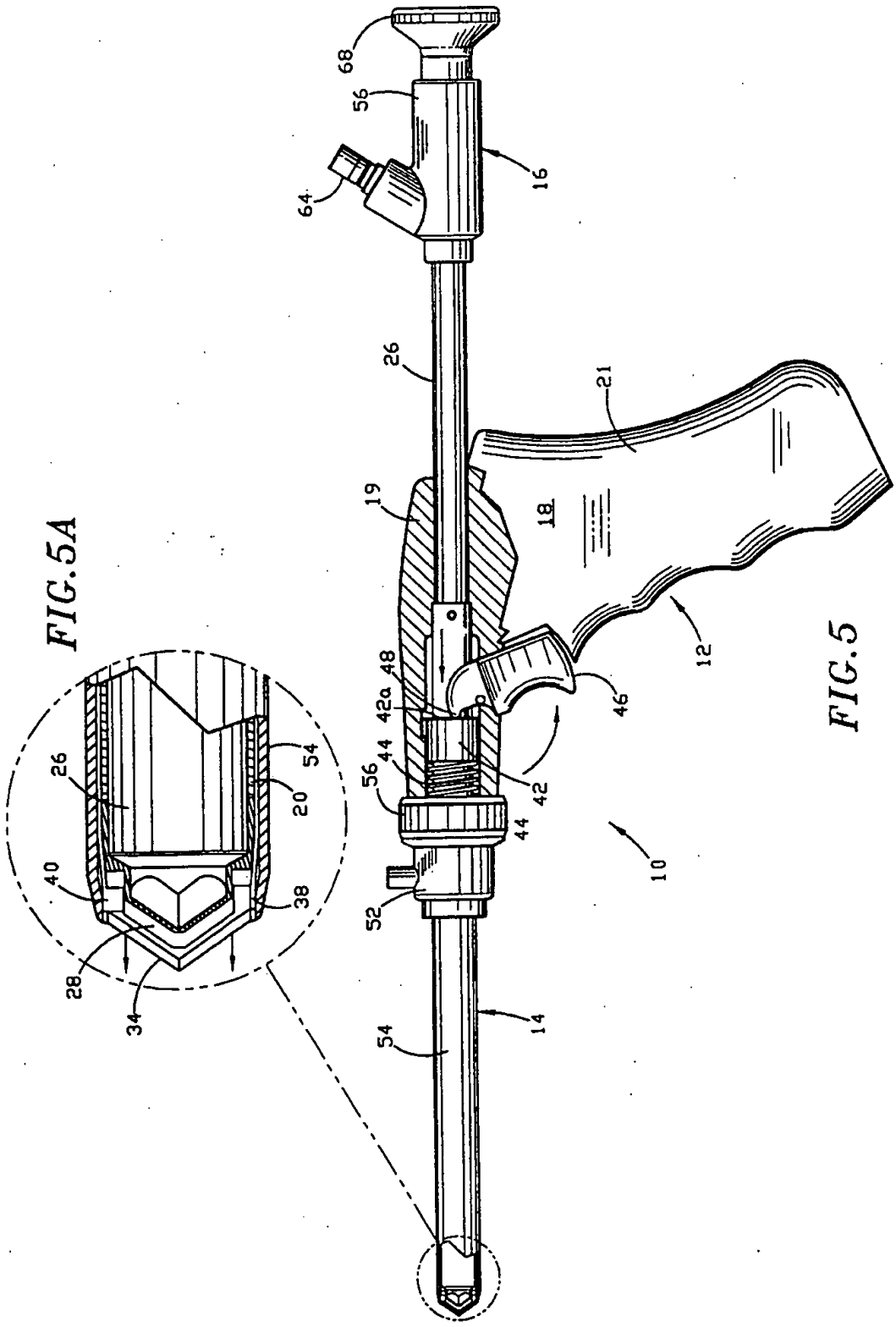

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FIG. 5

FIG. 5A

OPTICAL TROCAR

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an apparatus for penetrating and for observing penetration of body tissue. More particularly, the present invention relates to a trocar assembly having an endoscope or laparoscope inserted therethrough to provide visual observation during penetration of the peritoneum or other body tissue.

2. Description of the Related Art

Endoscopic surgical procedures, that is, surgical procedures performed through tubular sleeves or cannulas, have been utilized for many years. Initially, endoscopic surgical procedures were primarily diagnostic in nature. More recently as endoscopic technology has advanced, surgeons are performing increasingly complex and innovative endoscopic surgical procedures. In endoscopic procedures, surgery is performed in any hollow viscus of the body through a small incision or through narrow endoscopic tubes (cannulas) inserted through small entrance wounds in the skin. In laparoscopic procedures surgery is performed in the interior of the abdomen.

Laparoscopic procedures generally utilize instrumentation that is internally sealed to inhibit gases from entering or exiting the body through the laparoscopic or endoscopic incision. This is particularly true in surgical procedures in which the surgical region is insufflated. Moreover, laparoscopic and endoscopic procedures often require the surgeon to act on organs, tissues and vessels far removed from the incision, thereby requiring that any instruments to be used in such procedures be of sufficient size and length to permit remote operation. Typically, after the surgical region is insufflated, trocars are used to puncture the body cavity and include a cannula which remains in place for use during endoscopic procedures. Generally, trocars used during such procedures include a styler having a sharp tip for penetrating the body cavity positioned coaxially within protective tubes to protect a patient or surgeon from inadvertent contact with the tip. An example of a known trocar is described in commonly assigned, U.S. Pat. No. 4,601,710 to Moll. Most currently used trocars rely on protective tubes or relative retraction of the tip to prevent inadvertent contact with tissue.

The present invention provides a trocar assembly for observing the penetration of the peritoneum or other body portions. The trocar assembly of the present invention provides an improved structure for directing optical images which provides a clear and bright image of the body tissue being penetrated. In addition, the present invention provides an improved cutting tip for penetration of body tissue.

SUMMARY OF THE INVENTION

The present invention relates to an optical obturator which includes a sleeve having a longitudinal bore between a proximal end and a distal end. The longitudinal bore of the sleeve is configured to receive at least a portion of an endoscope or like image transferring system. An image directing member is positioned at the distal end of the sleeve and is provided to direct optical images into the longitudinal bore of the sleeve. A movable blade is positioned distal to the image directing member to facilitate penetration of body tissue.

The present invention also provides a trocar which includes a cannula assembly, an obturator assembly and an image transferring system. The cannula assembly includes a cannula housing and a cannula sleeve extending from said cannula housing. The obturator assembly includes an obturator sleeve having a proximal end, a distal end and a longitudinal bore therebetween which are configured for coaxial alignment with the cannula assembly.

An image directing member is positioned at the distal end of the obturator sleeve and is provided to direct optical images into the longitudinal bore of the sleeve. A tissue penetrating member, such as a blade, is positioned adjacent the distal end of the obturator sleeve and distal to the image directing means and is preferably movable between non-deployed and deployed positions. Preferably, the tissue penetrating member is configured to facilitate observation of body tissue simultaneous with penetration of body tissue.

In the preferred embodiment, the image directing member includes a prism having four substantially flat surfaces for receiving optical images. Alternatively, the image directing means includes a lens having at least one conical surface for receiving optical images.

The present invention also provides an apparatus for simultaneous observation of penetration of body tissue which includes a cannula assembly having a cannula housing and a cannula sleeve extending from the cannula housing. Typically, the cannula sleeve has a longitudinal bore extending from a proximal end to a distal end. An obturator assembly having an obturator housing and an obturator sleeve is provided to interfit with the cannula assembly. A distal end of the obturator sleeve has an image directing member secured thereto configured to direct optical images into the bore of the obturator sleeve. The apparatus also includes tissue penetrating means positioned distal to the image directing member and movable between non-deployed and deployed positions. In addition, image transferring means, such as an endoscope, is positioned within the longitudinal bore of the obturator sleeve and is provided to transmit optical images from the image directing member to a proximal end of the obturator housing for subsequent viewing by the surgeon.

BRIEF DESCRIPTION OF THE DRAWINGS

The preferred embodiments of the invention are described hereinbelow with reference to the drawings wherein:

FIG. 1 is a side elevational view in partial cross-section of the apparatus according to the present invention, illustrating an endoscope positioned within a trocar assembly having a movable cutting blade;

FIG. 1A is an enlarged partial cross-sectional view of the distal end of the apparatus of FIG. 1, illustrating the cutting blade in a non-deployed position;

FIG. 2 is an exploded perspective view of the instrument of FIG. 1 with parts separated, illustrating an actuating assembly for moving the cutting blade;

FIG. 2A is an exploded perspective view of an image directing member and blade according to the present invention;

FIG. 2B is a cross-sectional view of the obturator sleeve of the present invention;

FIGS. 3 and 4 illustrate alternative embodiments for the configuration of the image directing member according to the present invention;

FIG. 5 is a side elevational view similar to FIG. 1, illustrating actuation of the trigger assembly to move the blade to a deployed position; and

FIG. 5A is an enlarged partial cross-sectional view of the distal end of the apparatus of FIG. 5, illustrating the cutting blade in the deployed position.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The apparatus of the present invention is provided to penetrate body tissue, e.g., the abdominal wall, and to provide a simultaneous forward directional view of the body tissue being penetrated. In the preferred embodiment, the apparatus includes a trocar assembly **10** having an obturator assembly **12** and a cannula assembly **14**, and an endoscope **16** which is positioned within the obturator assembly to provide observation of the body tissue being penetrated.

Referring to FIGS. **1** and **2**, obturator assembly **12** includes housing **18** and a longitudinally extending obturator sleeve **20**. Preferably, obturator housing **18** includes barrel portion **19** and hand grip **21**. The proximal end of obturator sleeve **20** is secured within channel **22** of barrel portion **19** so that the obturator sleeve **20** extends outwardly from the obturator housing **14**. Hand grip **21** is provided for manual gripping to facilitate penetration of the body tissue. Obturator sleeve **20** has a longitudinal bore **24** which extends between the proximal end and distal end. The longitudinal bore **24** is configured and dimensioned to receive the endoscopic portion **26** of the endoscope **16**, as shown in FIG. **1**.

Referring to FIGS. **2**, **3** and **4**, image directing member **28** is secured to the distal end of obturator sleeve **20** via retaining ring **30**. In this configuration, optical images which impinge the distal end **28***a* of image directing member **28** are directed into longitudinal bore **24** of obturator sleeve **20**. The image directing member may be a lens, an optical prism, an optical mirror, or like image directing medium and is preferably configured to allow a 360° forward angle of view. In the preferred embodiment, image directing member **28** is a prism which includes a set of four substantially flat surfaces **28***b*, **28***c*, **28***d* and **28***e*, as shown in FIG. **3**. The flat surfaces direct the optical image into the longitudinal bore of the obturator sleeve so as to provide a clear image. Alternatively, the image directing member is a lens which includes a set of two conical surfaces **28***f* and **28***g* which direct an optical image into the longitudinal bore **24** of obturator sleeve **20** (see FIG. **4**).

Referring again to FIG. **2**, the cutting portion **32** of obturator assembly **12** includes a cutting blade **34** connected to actuating assembly **36**. Actuating assembly **36** is provided to move blade **34** between a non-deployed position (FIG. **1A**) and a deployed position (FIG. **5A**) which will be described in more detail below. The cutting blade **34** is preferably centered with respect to the outer surface of the image directing member as shown. Thus, in visulization, the cutting blade is seen as a thin line through the center, i.e. bisecting, the viewing field so as not to obstruct viewing of the body.

Actuating assembly **36** includes blade pusher arms **38** and **40**, blade drive member **42**, drive spring **44** and trigger **46**. Blade **34** is connected such as by welding, to the distal end of blade pusher arms **38** and **40** which extend along the longitudinal axis of obturator sleeve **20** within slots **39** and **41** in obturator sleeve **20**, shown in FIG. **2B**. The proximal end of blade pusher arms **38** and **40** are secured within slots **43** and **45** of blade drive member **42**, as shown. Blade drive member **42** and drive spring **44** are positioned within channel **22** of obturator housing **18** so that drive spring **44** normally biases blade drive member **42** toward the proximal end of obturator housing **18**, thus biasing blade **34** to the proximal non-deployed position.

Trigger **46** is pivotally secured to obturator housing **18** via pin **47**, as shown, so that camming surface **48** of trigger **46** engages the proximal end portion **42***a* of blade drive member **42**. Thus, actuation of trigger **46**, i.e. movement in the direction of the arrow in FIG. **5**, causes camming surface **48** to engage blade drive member **42** and move the drive member distally within channel **22**. Distal movement of drive member **42** causes blade pusher arms **38** and **40** to move distally to move blade **34** distally to the deployed (extended) position. Release of trigger **46** permits blade **34** to return to the non-deployed position in response to the action of drive spring **48** forcing blade drive member **42** proximally.

The movement of blade **34** between non-deployed and deployed positions can be seen by comparing FIGS. **1** and **5**. As shown in FIGS. **1** and **1A**, in the non-deployed position the blade **34** is at rest within recess **50** (FIG. **2A**) in image directing member **28**. In the deployed position blade **34** is extended from recess **50** beyond the distal end of cannula assembly **14**, as shown in FIG. **5**.

With reference to FIG. **2**, cannula assembly **14** includes cannula housing **52** and cannula sleeve **54** secured to the cannula housing **52** and extending outwardly therefrom. Obturator housing **18** includes bushing **56** which is configured and dimensioned to interfit with the proximal end of cannula housing **52**, as shown in FIG. **1**, so that obturator sleeve **20** coaxially aligns with cannula sleeve **54** when the two assemblies are interfitted. The cannula sleeve **54** is adapted to remain in the body after penetration and subsequent removal of the obturator assembly **12** (and endoscope **10**) to allow insertion of appropriate endoscopic/laparoscopic instrumentation therethrough.

To maintain a gas tight seal within the cannula housing, a sealing member or system may be positioned therewithin which is adapted to receive the obturator assembly **12** of the present invention as well as other endoscopic surgical instruments. One example of a suitable sealing system utilizes a duckbill sealing member. A more detailed description of an exemplary cannula assembly and sealing system is found in U.S. Pat. No. 5,180,373 issued Jan. 19, 1993, which is incorporated herein by reference.

Referring to FIGS. **1A** and **2**, endoscope **16** includes endoscopic portion **26** and endoscope housing **58**. Endoscopic portion **26** is configured to transfer illuminating light from endoscope housing **58** to the distal end of the endoscopic portion to provide illuminating light to the operative site. In an exemplary configuration, endoscopic portion **26** includes an outer sheath **60** and an annular array of fiber optic elements **62** extending between light source connector **64** of endoscope housing **58** and the distal end of outer sheath **60** to illuminate the operative site. Any known light source may be connected to connector **64** to provide the illuminating light. In addition, endoscopic portion **26** includes an image transferring system **66** which may include a bundle of fiber optic elements or objective lenses which transfer

an optical image to eyepiece 68 for viewing. Alternatively, a video system including a monitor may be operatively connected to housing 58 to provide a video image of the body tissue being penetrated. Preferably, the fiber optic elements 62 are positioned adjacent the inner wall of the outer sheath so as to surround the image transferring system. In this configuration, optical images which impinge on the image directing member 28 are directed into the image transferring system and relayed to eyepiece 68. An example of an endoscope which can be utilized is described in U.S. Pat. No. 4,964,710 incorporated herein be reference.

In operation, endoscope 16 is inserted into the trocar assembly 10, i.e. into longitudinal bore 24 of obturator sleeve 20, as shown in FIG. 1. The surgeon then positions the blade 34 against the body tissue and may continuously move blade 34 between the non-deployed and deployed positions, i.e., reciprocally moving blade 34, via actuating assembly 32. Pressure is applied to hand grip 21 in the distal direction to penetrate the body tissue. The movement of blade 34 facilitates cutting of the body tissue, thus permitting the surgeon to apply minimal pressure to hand grip 21 to penetrate the body tissue.

During penetration of the body tissue the surgeon either observes such penetration through eyepiece 68, or in instances where a video system is utilized the surgeon simply observes the penetration of the body tissue via any known video monitor.

Once the surgeon penetrates the body tissue as observed through endoscope 16, the surgeon releases trigger 46 to permit blade 34 to return to the non-deployed position and discontinues application of pressure to hand grip 21.

In operation, the surgeon may also more selectively deploy the blade 34 during penetration. That is, the surgeon may insert the trocar assembly and bluntly penetrate the body tissue until reaching thicker tissue, such as muscle. At this point, the blade can be deployed to penetrate (cut through) this thick tissue, then retracted to provide blunt penetration until thick tissue is again encountered where once again the blade can be deployed.

After penetration into the body cavity, both the endoscope 16 and the obturator assembly 12 are removed from the cannula assembly 14, leaving the cannula assembly 14 in the body for insertion of desired instrumentation therethrough.

In an alternate embodiment, the obturator assembly 12 and endoscope 16 or optical components thereof can be a single unit inserted into cannula assembly 14. For example, the obturator assembly can be manufactured with illumination optics and/or imaging optics positioned therein so that the obturator assembly itself can function to penetrate tissue as well as to light the surgical site and transmit images to the video monitor. In this version, the obturator would not have a longitudinal bore and it would be sealed.

It will be understood that various modifications can be made to the embodiments of the present invention herein disclosed without departing from the spirit and scope thereof. For example, various diameters for the cannula assembly, the obturator assembly, as well as various diameter endoscopes are contemplated. Also, various modifications may be made in the configuration of the parts. Therefore, the above description should not be construed as limiting the invention but merely as exemplifications of preferred embodiments thereof. Those skilled in the art will envision other modifications within the scope and spirit of the present invention as defined by the claims appended hereto.

What is claimed is:

1. An optical obturator which comprises:
- a sleeve having a longitudinal bore between a proximal end and a distal end, said longitudinal bore of said sleeve being configured to receive at least a portion of an endoscope;
- an image directing member positioned adjacent said distal end of said sleeve for directing optical images into said longitudinal bore of said sleeve;
- a cutting blade for penetrating body tissue positioned distal to said image directing member and in operative association with said distal end of said sleeve, said cutting blade being movable between non-deployed and deployed positions; and
- an actuator operatively connected to the cutting blade, the actuator being selectively movable to move the cutting blade between the non-deployed and deployed positions.

2. The optical obturator according to claim 1, wherein said image directing member comprises a prism having four substantially flat surfaces for receiving optical images.

3. The optical obturator according to claim 1, wherein said image directing member comprises a lens having at least one substantially conical surface for receiving optical images.

4. The optical obturator according to claim 1, wherein said image directing member provides a substantially 360 degree forward angle of view through said image directing means.

5. An optical obturator which comprises:
- a sleeve having a longitudinal bore between a proximal end and a distal end, said longitudinal bore of said sleeve being configured to receive at least a portion of an endoscope;
- an image directing member positioned adjacent said distal end of said sleeve for directing optical images into said longitudinal bore of said sleeve, said image directing member providing a substantially 360 degree forward angle of view through said image directing member;
- means for penetrating body tissue positioned distal to said image directing member and in operative association with said distal end of said sleeve, said means for penetrating body tissue comprising a cutting blade movable between non-deployed and deployed positions, said blade being operatively connected to actuating means such that actuation of said actuating means moves said blade between said non-deployed and deployed positions;
- a blade drive member slidably positioned with said sleeve;
- at least one blade pusher arm extending between said blade and said blade drive member; and
- a trigger member operatively connected to said sleeve, said trigger member having a camming surface which engages said blade drive member and moves said blade drive member in response to movement of said trigger member.

6. A trocar which comprises:
- a cannula assembly having a cannula housing and a cannula sleeve extending from said cannula housing;

an obturator sleeve configured for insertion into said cannula assembly, said obturator sleeve having a proximal end, a distal end and a longitudinal bore;

means positioned at said distal end of said obturator sleeve for directing optical images into said longitudinal bore;

a cutting blade for penetrating body tissue positioned at said distal end of said obturator sleeve and distal to said means for directing optical images so as to facilitate observation of body tissue simultaneous with penetration of body tissue, said cutting blade being movable between non-deployed and deployed position; and

an actuator operatively connected to the cutting blade, the actuator being selectively movable to move the blade between the non-deployed and deployed positions.

7. The trocar according to claim 6, wherein said means for directing optical images comprises a prism having four substantially flat surfaces for receiving optical images.

8. The trocar according to claim 6 wherein said means for directing optical images comprises a lens having at least one substantially conical surface for receiving optical images.

9. An apparatus for observation of body tissue during penetration comprising:

a sleeve having a proximal end and a distal end, said distal end having a movable cutting blade for penetrating body tissue;

means positioned in said sleeve for removably receiving an endoscope to allow viewing of body tissue and

an actuator operatively connected to the cutting blade and selectively movable between a first position to move the blade to an extended position and a second position to move the blade to a retracted position.

10. The instrument according to claim 9, wherein said receiving means comprises a longitudinal bore.

11. The instrument according to claim 10, wherein said sleeve is configured and dimensioned for insertion through a cannula.

12. An apparatus for observation of body tissue during penetration comprising:

a sleeve having a proximal end and a distal end, said distal end having a blade for penetrating body tissue, said sleeve configured and dimensioned for insertion through a cannula and said blade being movable between non-deployed and deployed positions; and

a longitudinal bore positioned in said sleeve for removably receiving an endoscope to allow viewing of body tissue, and

a trigger for moving said blade between said non-deployed and deployed positions.

13. An apparatus for observation of body tissue during penetration comprising:

a sleeve having a proximal end and a distal end, said distal end having a blade for penetrating body tissue, said sleeve being configured and dimensioned for insertion through a cannula, and said blade being movable between non-deployed and deployed positions; and

a longitudinal bore positioned in said sleeve for removably receiving an endoscope to allow viewing of body tissue, wherein said blade is spring biased to a non-deployed position.

14. The instrument according to claim 12, further comprising at least one reciprocating rod positioned within said sleeve and operatively connected to said blade at a first end and to said trigger at a second end.

* * * * *

US005591192A

United States Patent [19]

Privitera et al.

[11] Patent Number: 5,591,192

[45] Date of Patent: Jan. 7, 1997

[54] SURGICAL PENETRATION INSTRUMENT INCLUDING AN IMAGING ELEMENT

[75] Inventors: Salvatore Privitera, West Chester; Richard F. Schwemberger; Ron Kolata, both of Cincinnati, all of Ohio

[73] Assignee: Ethicon Endo-Surgery, Inc., Cincinnati, Ohio

[21] Appl. No.: 384,505

[22] Filed: Feb. 1, 1995

[51] Int. Cl.[6] A61B 1/00

[52] U.S. Cl. 606/185; 604/164; 600/114

[58] Field of Search 600/114, 117, 600/104, 129, 160, 137, 138, 165, 176; 606/185, 167; 604/164, 264

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Primary Examiner—Richard J. Apley

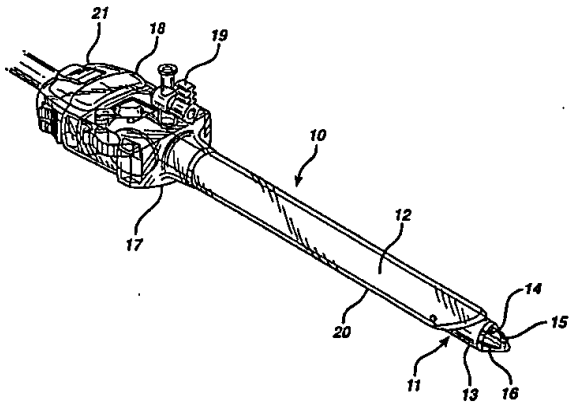
Assistant Examiner—Beverly M. Flanagan

Attorney, Agent, or Firm—Matthew S. Goodwin

[57] ABSTRACT

A surgical instrument for penetrating bodily tissue including an imaging element providing the capability for simultaneous visualization during penetration is disclosed. A transparent portion of the imaging element extends from the distal end of an elongated, substantially hollow shaft. The imaging element is shaped to enlarge an opening as the instrument is advanced into bodily tissue, and an endoscope can be inserted through the shaft adjacent the imaging element to visualize the penetration of tissue as the instrument is advanced. The imaging element may be substantially hollow, and have an annular interior region inside the shaft distal end. The endoscope can then be positioned to rest on the annular region to prevent glare from the reflection of light traveling from the endoscope to the window surface. The imaging element may also have a blade for facilitating the advance of the instrument through tissue. The blade not only has a sharp, linear cutting edge, but also a blunt edge for preventing inadvertent cutting of tissue. The blunt edge is preferably located near the tip and base of the imaging element. Additionally, the imaging element is generally conical and the penetrating surface has a region extending at an obtuse angle relative to the exterior surface of the conical element, and a second region extending generally parallel to the exterior surface of the conical element.

20 Claims, 6 Drawing Sheets



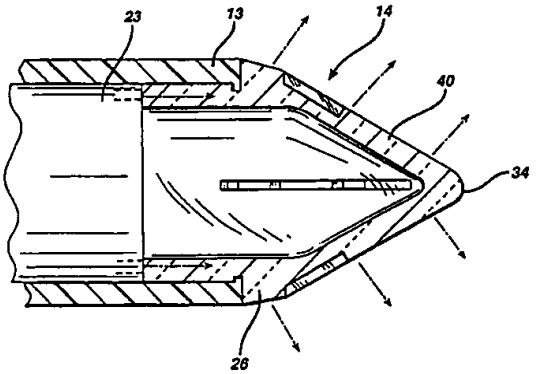


FIG. 1

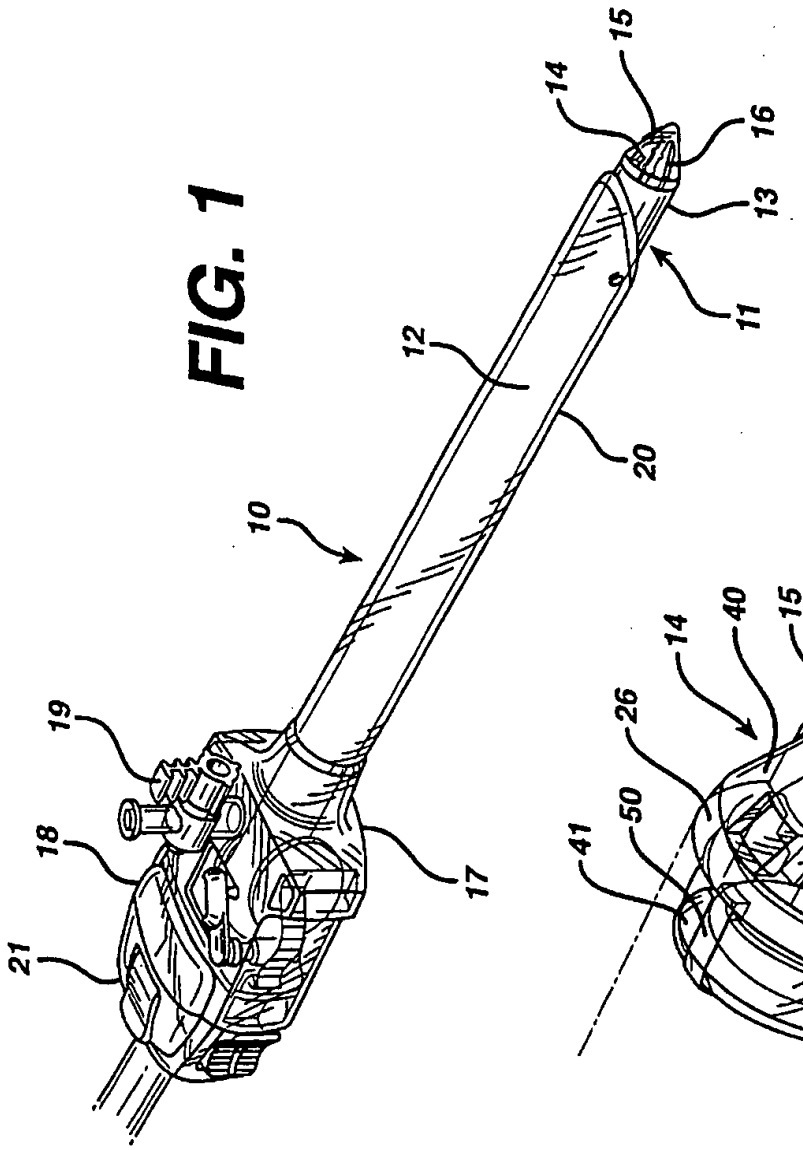


FIG. 2

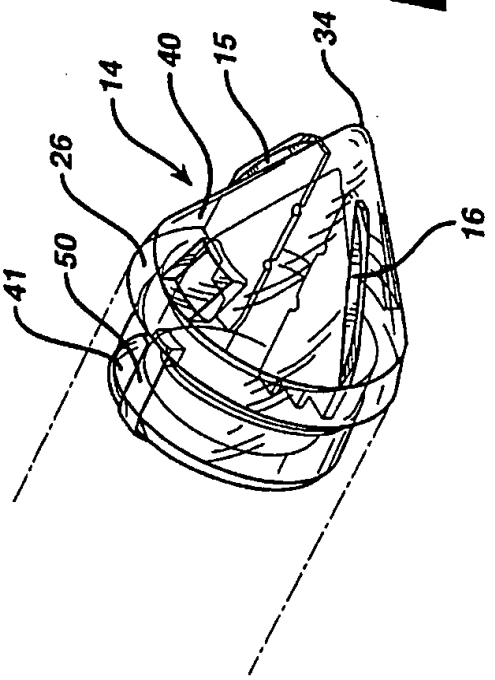


FIG. 3

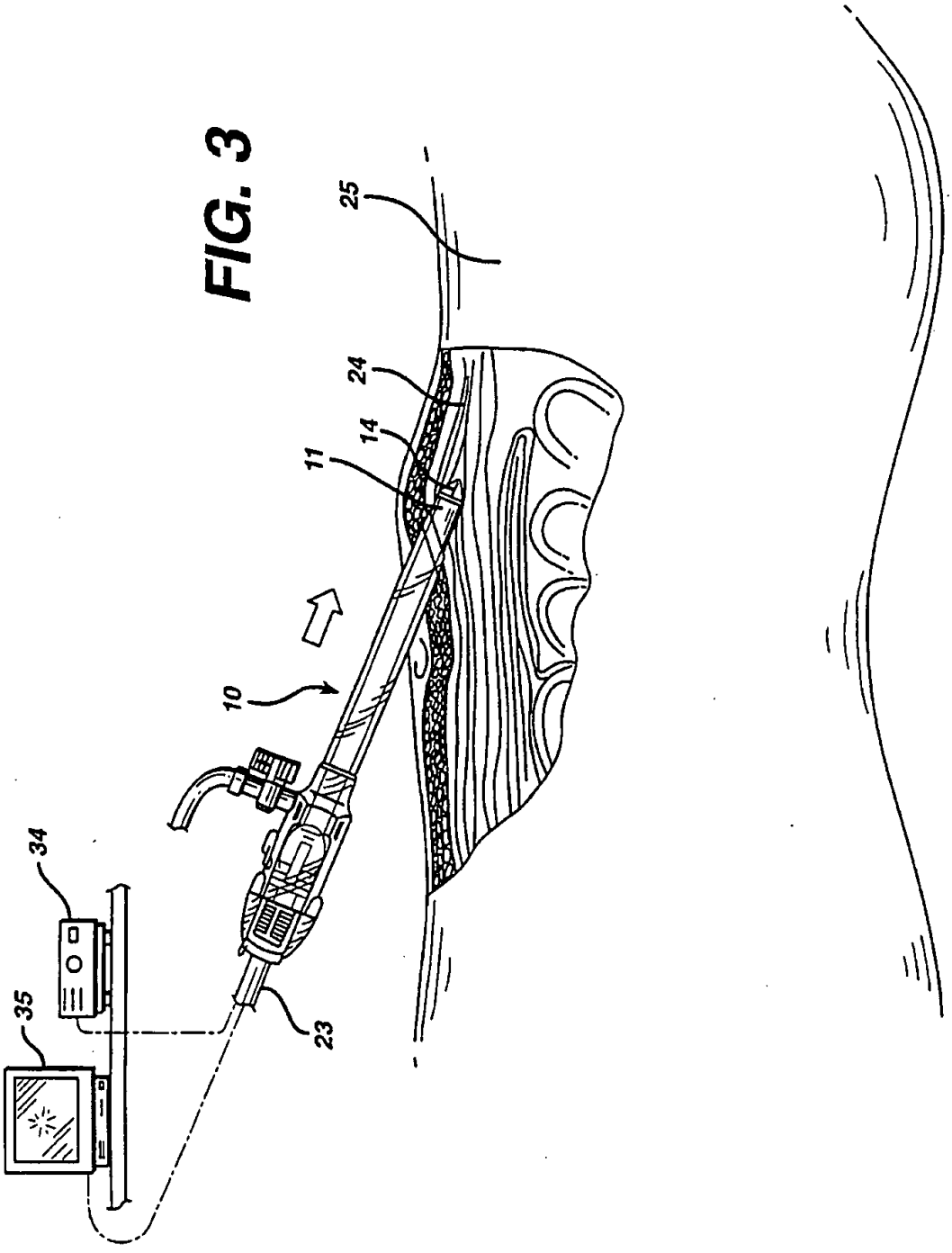


FIG. 4

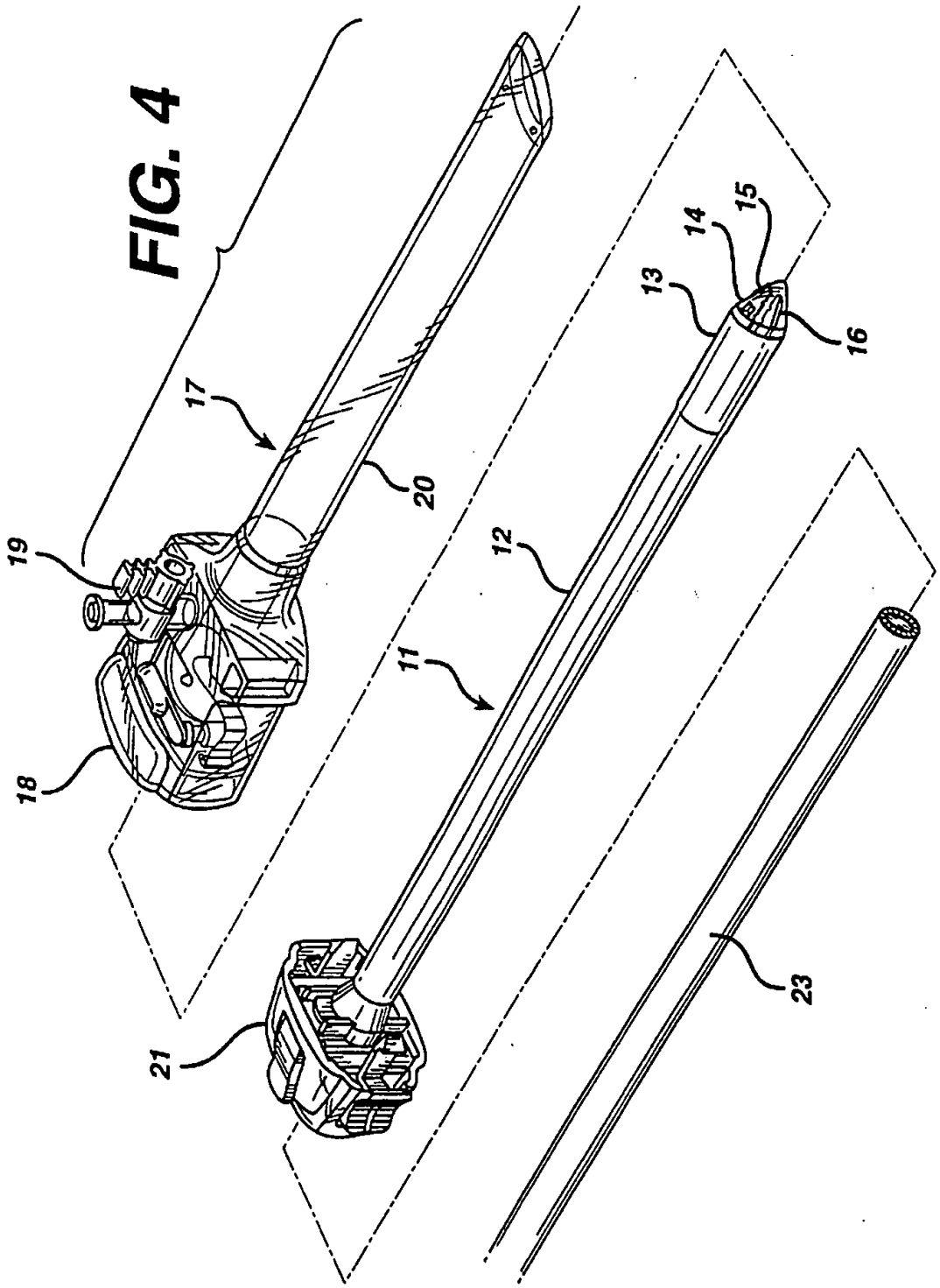


FIG. 5 PRIOR ART

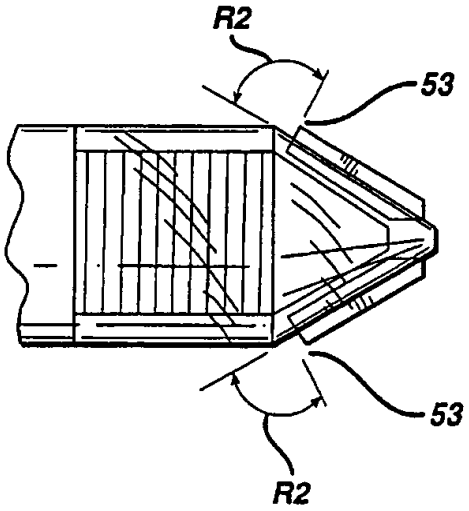


FIG. 6

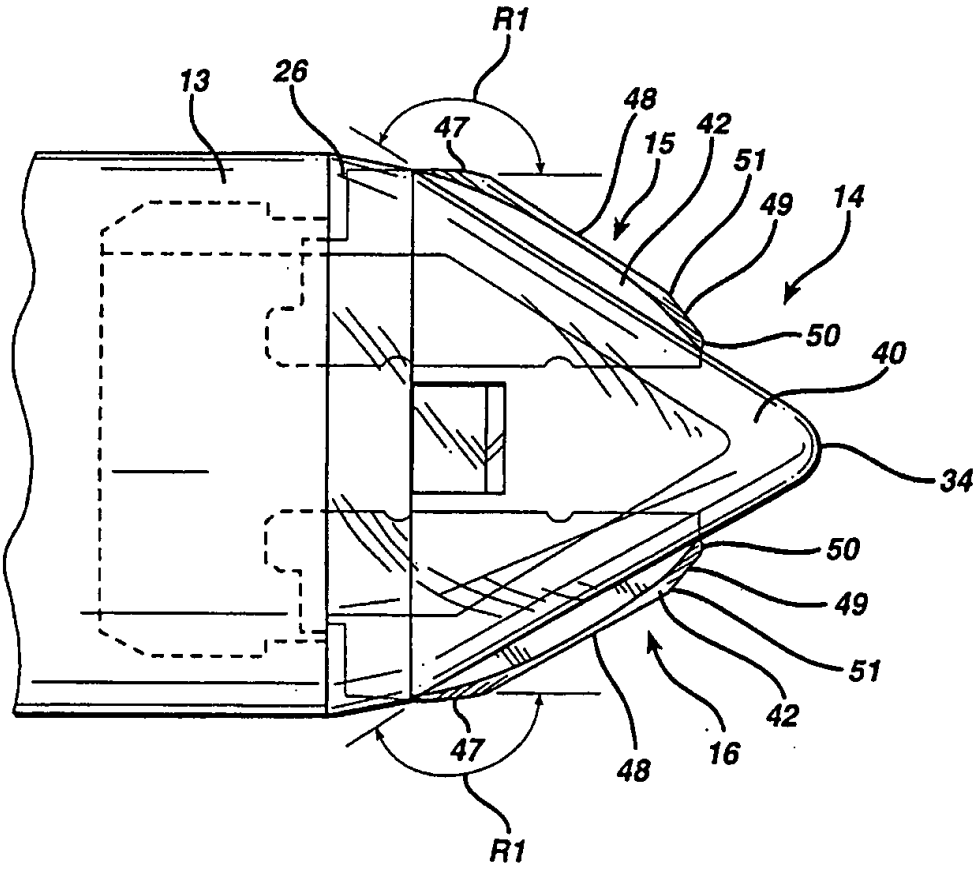


FIG. 7

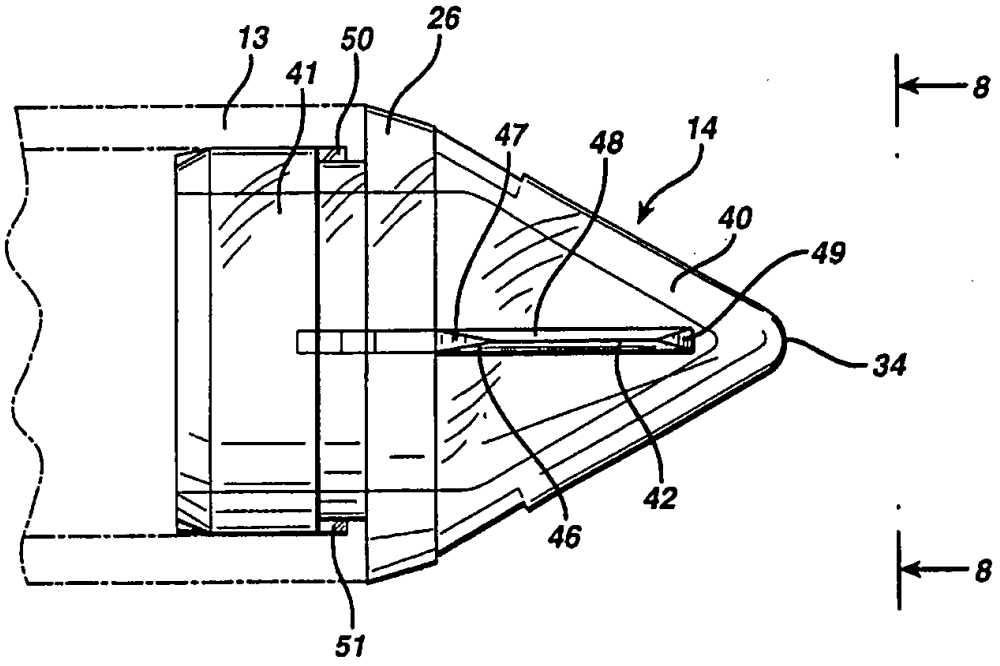

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FIG. 8

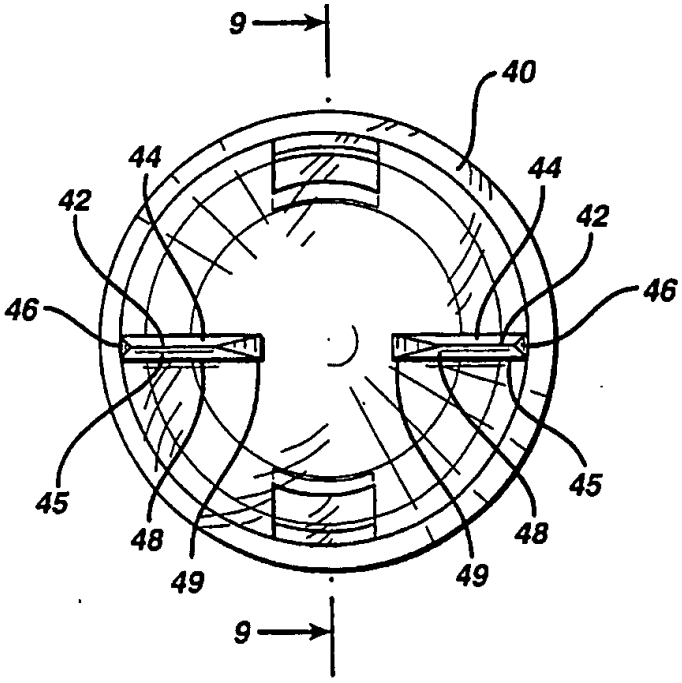
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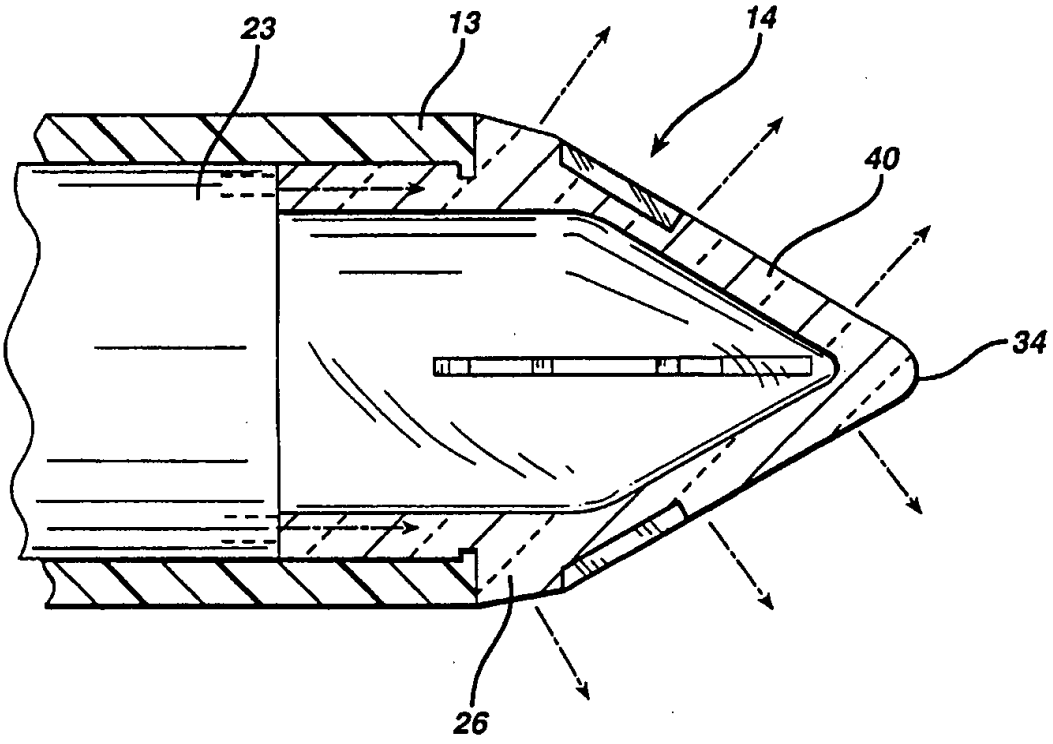
FIG. 9



SURGICAL PENETRATION INSTRUMENT INCLUDING AN IMAGING ELEMENT

BACKGROUND OF THE INVENTION

This invention relates to surgical instruments for penetrating or dissecting bodily tissue. More specifically, it relates to penetrating instruments which incorporate an imaging element for viewing. These instruments allow access into a body cavity when the instrument is advanced into the tissue, and simultaneously provide the ability to visualize the penetrated tissue during the advancement.

One of the key surgical activities which is required during every surgical procedure is the creation of an access opening into the body cavity at the desired surgical site. For many years, the surgeon created the access opening by simply making a large incision through the body wall to expose the body cavity. The length of the incision would depend on the size of conventional surgical instruments and the ability of the surgeon to properly and efficiently use these instruments within the body cavity through the incision created. Once the surgeon finished the surgical procedure, the incision could be fastened using known techniques. Unfortunately, due to the nature of these conventional, open surgical procedures, long incisions were often necessary. Open surgery can therefore be traumatic to the patient because, among other things, the recuperative period required to fully heal from the effects of the large incision may be significant.

Since a patient's recuperative period can be significant in connection with conventional open surgery, new surgical procedures and instruments to support those procedures are becoming available. The most popular alternative to open surgery currently is endoscopic surgery. Endoscopic surgery involves the use of a number of small diameter openings providing access into the body cavity. Unlike the large incisions required for open surgery, these small diameter openings readily heal following surgery, and require much less recuperation time for the patient.

The cornerstones which have made endoscopic surgical procedures possible are the miniaturized camera, or endoscope, and the surgical penetration instrument providing the small diameter opening for access into the body cavity, conventionally referred to as the trocar. Since both of these instruments are critical for the performance of endoscopic surgery, each will be discussed briefly below.

An endoscope is an elongated, generally cylindrical imaging and visualization instrument. It can be attached to a light source which provides illumination within the body cavity at the surgical site. The endoscope contains a miniaturized camera lens which is capable of transmitting the illuminated images at the surgical site to the surgeon during a surgical procedure. The endoscope is frequently attached to a video monitor during endoscopic surgery, so that the surgical team can observe the surgical procedure within the body cavity on the video monitor screen. The endoscope has made it possible to indirectly observe the surgical procedure without having the direct access into the body cavity, and consequently the large incisions it requires to create such direct access.

Critical to the success of endoscopic surgery is the creation of a small diameter passageway into the body cavity for subsequent insertion and withdrawal of surgical instruments. These instruments include, for example, an endoscope, and elongated instruments to cut, fasten, coagulate and excise desired tissue. The trocar has become the instrument of choice to create this small diameter passageway. A

trocar is a penetrating assembly including a cutting tool, commonly referred to as the trocar obturator. The obturator has an elongated, cylindrical shaft from which extends a penetrating tip to create and enlarge an opening into tissue as the obturator is advanced. The obturator is slidably received in a sleeve, commonly referred to as the trocar cannula. As the obturator is advanced into the tissue, the cannula likewise is advanced. When the obturator has completely punctured the body wall, the obturator is withdrawn from the trocar assembly, leaving behind the trocar cannula. The trocar cannula then provides the passageway into the body cavity through a relatively small diameter opening.

One of the first technical challenges in connection with the design and manufacture of the trocar related to the incorporation of features into the trocar to enhance its safety. Specifically, it was important to develop a safety trocar which could substantially lessen the possibility of unintentional tissue or organ puncture. The seminal patent that describes a mechanism for protecting bodily tissue and organs from inadvertent puncture during advancement of the instrument into the body cavity is U.S. Pat. No. 4,535,773 (Yoon, issued August, 1985). This patent describes a trocar assembly which includes a safety shield interposed between the trocar obturator and cannula. The shield is biased in an extended position to cover the penetrating tip of the obturator. When the surgeon desires to penetrate tissue with the trocar, the safety shield retracts and exposes the penetrating tip when the surgeon applies pressure against the body wall. The shield remains in the retracted position so long as pressure is continuously applied. When the surgeon fully punctures the body wall, the pressure is relieved and the safety shield returns to its extended position covering the penetrating tip. Therefore, inadvertent puncture of bodily tissue and organs within the body cavity can be avoided. Another trocar assembly with a safety shield mechanism is described in U.S. Pat. No. 5,226,426 (Yoon, issued Jul. 13, 1993). This patent describes a trocar obturator in the form of a hollow needle through which the safety shield (or safety "probe"), is disposed. Once again, the safety probe covers the sharp tip of the needle until pressure is applied during insertion.

Since the development of the safety-shielded trocar, other mechanisms for protecting tissues and organs from inadvertent puncture during endoscopic surgery have been developed. For example, mechanisms have been developed where the obturator retracts into the trocar cannula after puncture. These "retractable obturator" trocars may be equipped with a safety shield which simultaneously moves to an extended position as the obturator retracts within the trocar cannula.

While numerous trocar assemblies have been designed to prevent inadvertent puncture, all of these instruments still have one basic problem. Regardless of the safety mechanisms built into these instruments, the surgeon cannot avoid the fact that he is still puncturing tissue blindly. Not only is the puncture performed blindly, but the instruments are expensive to manufacture and occasionally fail in connection with the safety features incorporated to prevent inadvertent puncture during the blind insertion. Therefore, significant new designs for trocar assemblies have been developed.

One of the more remarkable developments in the design of trocar assemblies relates to the incorporation of visualization concurrently with penetration. This has been made possible by the "marriage" of the endoscope for imaging and visualization, and the trocar for penetration to provide the endoscopic access opening. The first patent to describe a

surgical penetration instrument adapted for visualization during penetration is U.S. Pat. No. 5,271,380 (Riek, et al., issued Dec. 21, 1993). The Riek patent describes a penetrating instrument including a hollow, cylindrical sleeve and an imaging element attached to the sleeve at its distal end. The imaging element is a transparent, optical "window". In a preferred embodiment, it has a conical configuration to facilitate the advance of the instrument into body tissue. A fiber optic cable extends through the hollow shaft and is positioned adjacent the proximal end of the window. It delivers light from a light source through the optical window into surrounding bodily tissue. A camera lens is also provided in the shaft to deliver illuminated images transmitted through the optical window to the surgeon. When the surgeon advances the instrument into bodily tissue, the surgeon can view the tissue in front of and surrounding the optical window during the penetration. This feature is significant because the surgeon can adjust the path of advancement if he approaches tissue or organs which should not be touched. In this way, the incorporation of a safety shield or another mechanism to protect tissue or organs from inadvertent puncture during a blind insertion is unnecessary.

Although the surgical penetration instrument described in the Riek patent represents a major advance in trocar technology, the clarity of images transmitted to the surgeon of the surrounding tissue during advancement is less than what would be optimally desired. Significantly, the transparent optical window is hollow, and the fiber optic cable delivering light into the surrounding tissue for illumination is spaced from the window surface. Light rays must therefore travel from the cable through the void of the hollow window before contacting the window surface. As light is carried from the fiber optic cable to the surface of the window, a significant proportion of that light will not pass through the window into the surrounding tissue, but rather reflect back into the camera lens. This reflection causes unwanted glare, and prevents optimum clarity during visualization.

In another embodiment, the Riek patent describes a second fiber optic cable for delivering light which extends through the window and is positioned at the tip of the window. While this cable does indeed contact the surface of the window, it only does so at the tip and therefore is unable to provide adequate illumination of the tissue surrounding the entire conical window. In other words, it can only provide illumination of tissue in front of the tip of the window.

Another recently issued patent representing yet another significant advance in the state of the art with respect to surgical penetration instruments providing simultaneous visualization is U.S. Pat. No. 5,334,150 (Kaali, issued Aug. 2, 1994). The Kaali patent also describes an instrument including an elongated hollow shaft to which is attached an imaging element in the preferred form of a transparent conical window. However, instead of extending a fiber optic cable and lens into fixed positions adjacent the proximal end of the transparent window within the hollow shaft, the Kaali patent describes using a fully integrated endoscope which can be inserted through the hollow shaft adjacent the window to provide illumination and visualization of tissue in front of and surrounding the transparent window during insertion. Unfortunately, once again the optical clarity of the surrounding tissue as the instrument is advanced is less than ideal. This is so because the transparent window in the specific embodiments illustrated in this patent are substantially solid. Depending on the material of construction for the window, visual distortion and other undesirable optical effects can occur when light travels through the solid mass of the window,

Another feature which has recently been added to the surgical penetration instruments described in the Riek and Kaali patents is a cutting blade extending outwardly from the transparent optical window to facilitate the advance of the instrument into tissue. Unfortunately, these blades may inadvertently cut unwanted tissues or organs and cause undesirable damage to gaskets and other delicate elements located within the housing of the cannula sleeve when the instrument is removed from the cannula sleeve.

It should now be apparent to the reader that while significant advances have been made in the development of surgical penetrating instruments adapted for simultaneous visualization, there are still certain problems which need to be overcome. For example, what is needed is a surgical penetration instrument which can provide visualization with the optimum degree of clarity. Additionally, such an instrument would desirably incorporate a blade outwardly of the transparent optical window which would not cause unintended trauma to tissue or damage delicate elements in the cannula housing of the instrument, but rather facilitate the advance of the instrument into tissue for ease of penetration.

SUMMARY OF THE INVENTION

In one aspect of the invention, the invention is an imaging element for a surgical penetration instrument. The instrument has an elongated, generally cylindrical shaft having a distal end and a shaft diameter. The shaft has a lumen through it for receiving an endoscope. The imaging element is attached at the distal end of the shaft. The imaging element is substantially hollow and comprises a generally circular base adjacent the distal end of the shaft. An exterior region extends distally from the base and has a surface configuration shaped to enlarge an opening as the instrument is advanced into bodily tissue. At least a portion of the exterior region is transparent. An annular interior region descends proximally from the base, and the interior region has an annulus diameter less than the base diameter. The interior region descends interiorly into the lumen of the distal end of the shaft.

The imaging element for the surgical penetration instrument of this invention incorporates an annular interior region within the distal end of the shaft. Significantly, when an endoscope is inserted through the lumen of the shaft to the shaft distal end, the periphery of the distal end of the endoscope can rest on the edge surface of the annular interior region of the imaging element. Therefore, the endoscope is not spaced from the surface of the imaging element. The light from the endoscope, which is emitted from the periphery of the distal end of the endoscope, will travel directly from the endoscope into the imaging element and exit the transparent portion of the exterior region of the imaging element to illuminate surrounding tissue as the instrument is advanced. Significantly, light received at the transparent portion of the exterior region does not travel through the void in the hollow window. Reflection of light is therefore avoided without a need to fabricate a solid window. Glare is substantially lessened or eliminated. In so doing, optimum optical clarity is achieved.

In another aspect of the invention, the invention is an imaging element for a surgical penetration instrument. The instrument has an elongated shaft having a distal end. The imaging element is attached at the distal end of the shaft and extends distally from the distal end of the shaft to a tip. At least a portion of the imaging element is transparent and has an exterior surface shaped to enlarge an opening as an

instrument is advanced into bodily tissue. The imaging element comprises a blade at the imaging element having a tissue contacting portion outwardly of the element. The blade extends from adjacent the distal end of the shaft toward the tip, and the tissue contacting portion of the blade has two sidewalls converging to a penetrating surface. The penetrating surface has first and second sections, in which the first section has a blunt edge surface extending from the exterior surface of the imaging element to the second section. The second section has a sharp, linear edge surface.

The incorporation of a blunt edge surface onto the penetrating surface of the blade dramatically reduces the risk of inadvertent cutting of tissue or organs as the instrument is advanced. Likewise, when the instrument is used with a cannula sleeve, it also dramatically reduces the risk of cutting gaskets, seals and other elements residing within the housing of the cannula sleeve during insertion and withdrawal from the sleeve. Instead, the blade, as it is particularly set forth in this invention, facilitates the enlargement of an opening as the instrument is advanced without inadvertently cutting or tearing the tissue during such advancement.

In yet another aspect of this invention, the invention is an imaging element for a surgical penetration instrument. The instrument has an elongated shaft having a distal end. The imaging element is attached at the distal end of the shaft and extends distally from the distal end of the shaft to a tip. At least a portion of the imaging element is transparent and has a generally conical exterior surface. The imaging element comprises a blade at the imaging element having a tissue-contacting portion outwardly of the element. The blade extends from adjacent the distal end of the shaft toward the tip, and the tissue-contacting portion of the blade has two side walls converging to a penetrating surface. The penetrating surface has first and second sections. The first section extends from the exterior surface of the imaging element adjacent the shaft distal end to the second section, and is displayed at an obtuse angle relative to the exterior surface. The second section is generally parallel to the exterior surface.

The angular relationship between the exterior surface of the imaging element and the first section of the penetrating surface of the blade provides a smooth transition to the second section of the penetrating surface. The smooth transition facilitates the gradual enlargement of an opening as the instrument is advanced into tissue or prevents inadvertent cutting or tearing of that tissue during such advancement. Significantly, this blade design can eliminate the need for a squared-off or sharp corner on the tissue-contacting portion of the blade. When a sharp corner can be eliminated, the risk of inadvertently cutting or tearing tissue as the instrument is advanced is substantially reduced. Likewise, damage to gaskets and seals when the instrument is inserted or withdrawn from a cannula sleeve can also be reduced.

In a further aspect of this invention, the invention is an imaging element for a surgical penetration instrument. The instrument has an elongated shaft and a distal end. The imaging element is attached at the distal end of the shaft and extends distally from the distal end of the shaft to a tip. At least a portion of the imaging element is transparent and has a generally conical exterior surface. The imaging element comprises a blade at the imaging element having a tissue-contacting portion outwardly of the element. The blade extends from adjacent the distal end of the shaft toward the tip, and the tissue-contacting portion of the blade has two sidewalls converging to a penetrating surface. The penetrating surface has first, second and third sections. The second section is interposed between the first and second sections, and is generally parallel to the exterior surface of the imaging element. The first section extends from the exterior surface of the imaging element adjacent the shaft distal end to the second section. The third section extends from the exterior surface of the imaging element at a position adjacent to or proximal of the tip of the imaging element to the second section. Significantly, the third section has a generally rounded corner.

The generally rounded corner displayed on the third section of the penetrating surface of the blade is another way to provide a smooth transition through the tissue as the penetrating surface of the blade is advanced, in contrast to a blade having a squared-off corner. The smooth transition promotes less traumatic penetration or dissection of tissue as the instrument is advanced distally. An opening is gradually enlarged as the tissue contacts the rounded corner of the blade. Therefore, inadvertent cutting or tearing of that tissue can be avoided.

The surgical penetration instrument of this invention is ideally suited for all applications for which conventional trocars are used. These applications include, but are not limited to, various forms of endoscopic surgery, including laparoscopic and thoracoscopic surgery. It is also envisioned that the surgical penetration instrument of this invention may be used for arthroscopic surgery as well. In addition to those procedures where penetration and puncture of the body wall to provide a passageway for additional endoscopic surgical instrumentation is desired, it is also anticipated that this instrument may be used in procedures not requiring complete penetration and puncture through the body wall. For example, certain procedures require a penetrating or dissecting instrument to tunnel through layers of tissue without breaking certain other layers of tissue. Emerging procedures in connection with laparoscopic hernia repair and saphenous vein harvesting for cardiovascular surgery incorporate tunneling techniques to provide access to a desired surgical site remote from the point of entry. The surgical user may well find the surgical penetration instrument of this invention, which offers the dual capabilities of dissection and visualization, to be particularly well suited for these emerging procedures. Finally, the reader must also realize that although this instrument is particularly adapted for endoscopic surgical applications, it may also find use for a wealth of applications in conventional open surgery.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of an assembly including the surgical penetration instrument with the imaging element of the present invention.

FIG. **2** is an enlarged perspective view of the imaging element of the instrument.

FIG. **3** is a side elevational view and partial cross-section of the assembly including the instrument shown in the process of penetrating bodily tissue in a surgical patient.

FIG. **4** is an exploded perspective view of the assembly including the surgical penetration instrument with the imaging element.

FIG. **5** is a top plan view of an imaging element of the prior art.

FIG. **6** is an enlarged top plan view of the imaging element of the present invention.

FIG. **7** is a side elevational view of the imaging element.

FIG. **8** is an end elevational view of the distal tip of the imaging element as seen along view line **8—8** of FIG. **7**.

FIG. 9 is a side cross-sectional view of the imaging element indicating the path of light transmission when the distal end of an endoscope abuts the imaging element.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Reference numerals are used in this description to designate the various components and elements of the surgical penetration instrument of this invention. Identical reference numerals designated in the various drawings refer to the identical element or component of the surgical penetration instrument. As used in this description, "proximal" or "proximally" refers to that portion of the instrument, component or element which extends toward the user. Conversely, "distal" or "distally" refers to that portion of the instrument, component or element which extends away from the user.

Referring now to FIGS. **1**, **2** and **4**, there is a shown an assembly **10** which incorporates a surgical penetration instrument having the imaging element which is the subject of the claimed invention. The surgical penetration instrument **11** has a cylindrical, elongated hollow shaft **12**. The hollow shaft is sized for receiving a conventional endoscope. The shaft has a distal end **13** from which extends a portion of the imaging element **14**. The imaging element is hollow and entirely transparent, and is ideally a one-piece construction. In other words, it is advantageously composed of a single piece of material, such as a plastic or a glass. Facilitating the penetration of imaging element **14** as instrument **11** is advanced into tissue are first and second blades **15** and **16**, respectively, extending outwardly from the transparent imaging element.

The assembly includes a conventional cannula **17**. The cannula has a cannula housing **18** and stopcock **19**. Extending distally from the cannula housing **18** is the cannula sleeve **20**. The surgical penetration instrument **11** is inserted into and through the cannula housing **18** and sleeve **20**. The transparent imaging element **14** of the instrument, and a portion of the shaft distal end **13** of the instrument, extend distally from the cannula sleeve **20**.

The surgical penetration instrument **11** has at its proximal end an instrument hub **21**. The hub can be attached to the cannula housing **18** when the instrument is inserted into and through the cannula housing and sleeve. If desired, a pressurizing fluid such as carbon dioxide can be selectively pumped through the cannula sleeve **20** via stopcock **19** into the body of the patient.

The assembly illustrated in FIG. **1**, and in particular the surgical penetration instrument **11** including the transparent imaging element **14** of this invention, can be used to penetrate or dissect tissue while providing simultaneous visualization as the tissue is penetrated or dissected. As illustrated in FIG. **3**, the assembly **10** is advanced in the direction illustrated by the arrow through bodily tissue **24** of a surgical patient **25**. A conventional endoscope **23** can be inserted through the hollow shaft **12** of instrument **11** so that the endoscope is positioned adjacent the proximal end of transparent imaging element **14**. The endoscope **23** is connected to a light source **34** to provide illumination through the transparent penetrating tip **14** to the surgical site. It is also connected to a video monitor **35** to display the illuminated images transmitted from the surgical site. In this way, the user can readily monitor the advance of instrument **11** through bodily tissue **24** from video monitor **35**.

When the advancement of the surgical penetration instrument **11** is completed, the instrument and the endoscope **23** may be removed from cannula **17** of assembly **10**, so that additional instrumentation can then be inserted through the cannula to the surgical site to complete a desired surgical procedure.

Referring now to FIGS. **2** and **7**, the transparent conical imaging element **14** of this invention has a circular base **26** adjacent the shaft distal end **13**. An entirely transparent conical exterior region **40** having a generally tapering configuration in the form of a right circular cone, extends distally from the circular base to a blunt point **34**. Since the exterior region is entirely transparent, the transparent portion of the exterior region extends through substantially 360°. An annular interior region **41** having a diameter less than the diameter of circular base **26** descends proximally from the base into the lumen of the distal end of the shaft. The annular interior region **41** is generally in the form of a cylinder which has an outer wall diameter sized to frictionally contact the shaft distal end **13**. The annular interior region includes first and second longitudinally extending ribs **50** and **51** spaced about 180° apart. These ribs help to secure and seal the imaging element **14** to the shaft distal end **13**.

Accordingly, as best shown in FIG. **9**, when endoscope **23** is received into the lumen of hollow shaft **12** and extends to the shaft distal end **13**, the periphery of the endoscope abuts the annular interior region **41** of the transparent imaging element **14**. Consequently, light rays emitted from the endoscope **23**, which are emitted from the periphery of the endoscope, are delivered directly into and through the wall thickness of the hollow imaging element **14** into the surgical site. The pathway of the light rays emitted from endoscope **23** is shown generally by the arrows displayed in FIG. **9**.

Referring to FIGS. **2**, **6**, **7** and **8**, first and second blades **15** and **16** each have a tissue contacting portion **42** extending outwardly from the conical exterior region **40** of the transparent imaging element **14**. The tissue contacting portion of each blade includes first and second sidewalls **44** and **45**, respectively, which converge to form a penetrating surface **46**. The penetrating surface is a continuous surface, and includes first, second and third sections **47**, **48** and **49**, respectively. The first section extends from adjacent the circular base **26** to the second section **48**. The first section **47** has a blunt arcuate edge surface. The second section **48** extends from the first section to the third section **49**. The second section has a relatively sharp, linear edge surface. Finally, the third section **49** extends from the second section to adjacent the conical exterior region **40** of the imaging element **14** at a position proximal of the tip **34** of the imaging element. Similarly to the surface characteristic of the first section, the third section has a blunt arcuate edge surface.

First and second blades **15** and **16** are straight blades spaced approximately 180° from each other. The blades extend longitudinally in a plane parallel to the longitudinal-axis of the hollow shaft **12** and conical imaging element **14**.

Other aspects of the design of the blade configuration for the first and second blades **15** and **16** are illustrated in FIG. **6**. The first section **47** of each of the penetrating surfaces of the first and second blades extends distally from circular base **26** at an obtuse angle designated as R1 in relation to the surface line of the conical exterior region **40** of imaging element **14**. The second sections **48** of the penetrating surfaces for each of the blades extends generally parallel to the surface of the conical exterior region **40**. In addition, the third section **49** of the penetrating surfaces of the blades has a first rounded corner **50** adjacent the surface of the conical exterior region **40**, and a second rounded corner **51** spaced

from first rounded corner **50** and adjacent to the second section **48**.

In contrast, the prior art blade configuration, which is illustrated in FIG. **5**, has a squared-off proximal corner **53** adjacent the distal end of the shaft. Unlike the obtuse angle generated in connection with first section **46** of the penetrating surface of the imaging element **14** illustrated in FIG. **6**, the corresponding angle R2 generated in FIG. **5** is approximately 90°. Additionally, the prior art blade configuration also includes a squared-off distal corner **52**.

The reader should realize that this detailed description of the most preferred embodiment of the surgical penetration instrument, including the imaging element of this invention, does not preclude numerous additional embodiments which are not particularly illustrated in the drawings, but nevertheless fall within the scope of the appended claims. In other words, it is the appended claims which define the scope of the invention, and not this detailed description. One skilled in the art can readily envision numerous additional embodiments which fall within the scope of the appended claims. For example, the claimed invention should in no way be construed to be limited to an imaging element for a surgical penetration instrument requiring the incorporation of blades or a particular blade configuration. It may be desirable for certain embodiments to eliminate one or more of the blades because less traumatic advancement is desired. Alternatively, if blades are incorporated onto the imaging element, the invention should not be construed to limit the blade configuration to two straight blades. More than two blades can extend from the imaging element, or for that matter, only one blade may extend from the element and still be within the scope of the claimed invention. Similarly, the blade or blades need not be straight, but rather blades may be helical in form, or some other configuration.

What is claimed is:

1. An imaging element adapted for use with a surgical penetration instrument, said instrument having an elongated, generally cylindrical shaft having a distal end and a shaft diameter, said shaft having a lumen therethrough for receiving an endoscope to deliver light for illumination of a body cavity and to transmit an illuminated image from said body cavity through a camera lens of said endoscope, said imaging element attached at said shaft distal end;

wherein said imaging element is hollow and comprises a generally circular base adjacent said shaft distal end, said base having a base diameter substantially the same as said shaft diameter; an exterior region extending distally from said base and having a surface configuration shaped to enlarge an opening as said instrument is advanced into bodily tissue, at least a portion of said exterior region being transparent; and an annular interior region descending proximally from said base, said annular interior region having an annulus diameter less than said base diameter, said annular interior region descending interiorly into said lumen of said shaft distal end;

wherein when said endoscope is received in said lumen of said shaft, said endoscope abuts said annular interior region of said imaging element, said light delivered from said endoscope for illumination of said body cavity is emitted directly into said hollow imaging element so as to avoid reflecting said light into said camera lens of said endoscope to lessen unwanted glare on said illuminated image.

2. The imaging element of claim **1** wherein said exterior region has a generally tapering configuration extending distally from said base.

3. The imaging element of claim **2** wherein said exterior region is generally conical.

4. The imaging element of claim **3** wherein said exterior region is in the form of a right circular cone.

5. The imaging element of claim **4** wherein said transparent portion of said exterior region extends through substantially 360°.

6. The imaging element of claim **5** wherein said exterior region is entirely transparent.

7. The imaging element of claim **6** wherein said imaging element is an integral, one-piece element.

8. The imaging element of claim **7** wherein said imaging element is entirely transparent.

9. The imaging element of claim **8** wherein said imaging element further comprises a cutting element at said exterior region for facilitating the advance of said instrument into bodily tissue.

10. The imaging element of claim **9** wherein said cutting element is a blade having a sharp, linear edge.

11. An imaging element adapted for use with a surgical penetrating instrument, said instrument having an elongated shaft having a distal end, said imaging element attached at said shaft distal end and extending distally therefrom to a tip, at least a portion of said imaging element being transparent and having a generally conical exterior surface;

wherein said imaging element comprises a blade at said imaging element having a tissue contacting portion outwardly of said element, said blade extending from adjacent said shaft distal end toward said tip, said tissue contacting portion of said blade having two sidewalls converging to a penetrating surface, said penetrating surface having first and second sections, wherein said first section extends from said exterior surface adjacent said shaft distal end to said second section, said first section is displayed at an obtuse angle relative to said exterior surface, and said second section is generally parallel to said exterior surface.

12. The imaging element of claim **11** wherein said penetrating surface includes a third section extending from a position proximal of or adjacent to said tip of said imaging element to said second section, and said second section is interposed between said first and third sections.

13. The imaging element of claim **12** wherein said third section has a generally rounded first corner.

14. The imaging element of claim **13** wherein said third section has a generally rounded second corner spaced from said first corner.

15. The imaging element of claim **14** wherein said blade is a generally straight blade extending longitudinally.

16. The imaging element of claim **15** wherein said imaging element is a transparent conical element, and said conical element is in the form of a right circular cone.

17. An imaging element adapted for use with a surgical penetrating instrument, said instrument having an elongated shaft having a distal end, said imaging element attached at said shaft distal end and extending distally therefrom to a tip, at least a portion of said imaging element being transparent and having a generally conical exterior surface;

wherein said imaging element comprises a blade at said imaging element having a tissue-contacting portion outwardly of said element, said blade extending from adjacent said shaft distal end toward said tip, said tissue contacting portion of said blade having two sidewalls converging to a penetrating surface, said penetrating surface having first, second and third sections, wherein said second section is interposed between said first and third sections, and is generally parallel to said exterior surface of said imaging element, said first section extends from said exterior surface adjacent said shaft distal end to said second section at an obtuse angle

relative to said exterior surface, and said third section extends from a position proximal of or adjacent to said tip to said second section, and said third section has a generally rounded first corner.

18. The imaging element of claim 17 wherein said third section has a generally rounded second corner spaced from said first corner.

19. The imaging element of claim 18 wherein said blade is a generally straight blade extending longitudinally.

20. The imaging element of claim 19 wherein said imaging element is a transparent conical element, and said conical element is in the form of a right circular cone.

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